Regulation for B.Tech 2019
Mechanical Engineering

The A. P. J. Abdul Kalam Technological University Academic Regulations for B. Tech, 2019

This may be called the A. P. J. Abdul Kalam Technological University Academic Regulations for B. Tech, 2019. These are subject to the provisions of the APJ Abdul Kalam Technological University Act, 2015, the statutes and ordinances if any issued in the subject from time to time. It is the express understanding that these regulations are subject to the approval of the concerned statutory bodies of the University. These regulations shall be applicable for students admitted from 2019 onward.

	1. Preamble
R1.1	The University has the right to modify the regulations from time to time.
R1.2	In all matters related to the regulations, the decision of the University and its interpretation given by the BOG shall be final and binding.
	2. Admission
R2.1	Admission policy, eligibility for admission and admission procedure shall be decided by the University or the competent statutory authority for admissions from time to time.
R2.2	If at any time after admission, it is found that a candidate has not fulfilled any of the requirements stipulated by the University or the statutory body concerned, the Vice Chancellor may revoke the admission of the candidate and report the matter to the BOG.
R2.3	No student shall be permitted, under any circumstances, to change the branch/stream to which he/she is admitted by the competent authority for admission.
R2.4	A student admitted to a particular institute shall continue studying in that institute till the completion of the course, unless he/she is permitted an inter college transfer as per R9.1 to 9.12.
	3. Structure of B.Tech. Program.
R3.1	The duration of the B.Tech. Program shall be 4 years (8 semesters)
R3.2	The maximum duration shall be six academic years spanning 12 semesters.
R3.3	Every academic year shall have two semesters “1st July to 31st December (Odd semester)” and “1st January to 30th June (Even semester)”. Each semester shall have minimum of 72 working days. The vacation of the faculty and staff shall be as per the Government orders from time to time.
R3.4	Every branch of the B.Tech Program shall have a curriculum and syllabi for the courses approved by the Academic Council. Syllabus for any course shall be normally modified / updated once in four years. However, innovative elective courses can be included as

	and when required, on the recommendations of the respective Board of Studies and subject to the approval of the Academic Council. All revisions shall be based only on the recommendations of the Board of Studies concerned.
R3.5	The academic programs of the University follow the credit system. The general pattern is as below:

1 Hr. Lecture (L) per week	1 credit
1 Hr. Tutorial (T) per week	1 credit
1 to 2 Hours Practical(P) per week	1 credit
3 to 4 Hours Practical(P) per week	2 credit
The workload of a faculty member shall be the actual number of hours engaged by the faculty member.	

R3.6	The curriculum of any branch of the B.Tech. Program shall have a total of 160 academic credits and 2 additional pass/fail credits.
R3.7	Every course of B. Tech. Program shall be placed in one of the nine categories as listed in table below.

S. No.	Category	Code	Breakup of Credits
1	Humanities and Social Sciences including Management courses	HSMC	8
2	Basic Science courses	BSC	26
3	Engineering Science courses including workshop, drawing, basics of electrical/mechanical/computer etc	ESC	22
4	Professional core courses	PCC	76
5	Professional Elective courses relevant to chosen specialization/branch	PEC	15
6	Open subjects – Electives from other technical and /or emerging subjects ` as specified in the curriculum concerned.	OEC	03
7	Project work, seminar and internship in industry or elsewhere	PROJ	10
8	Mandatory Courses [Environmental Sciences, Induction training, Indian Constitution, Essence of Indian Traditional Knowledge]	MC	Non credit
9	Mandatory Student Activities (Pass/Fail)	SA	2
		Total Credits	162

R3.8	No semester shall have more than six lecture-based courses and two laboratory and/or drawing/seminar/project courses in the curriculum. Credit per semester shall not be less than 15 or greater than 25 and cumulative credits shall not be less than 162.
R3.9	The medium of instruction shall be English. All examinations, project/seminar reports and presentations shall be in English.
4. Academic Monitoring and Student Support.	
R4.1	Advisory System: There shall be one Senior Faculty Advisor (SFA) for a class and a faculty advisor (FA) each for 25 to 35 students in the class. The Principal shall assign a regular faculty member with minimum five years of experience as the Senior Faculty Advisor (SFA) in discussion with the Head of Department concerned.
R4.2	The documents regarding all academic and non academic matters of students under an advisory group shall be kept under the custody of Faculty Advisor/Senior Faculty Advisor.
R4.3	All requests/applications from a student or parent to higher offices are to be forwarded/recommended by his/her Faculty Advisor/Senior Faculty Advisor. Students and parents shall first approach their Faculty Advisor/ Senior Faculty Advisor for all kinds of advices, clarifications and permissions on academic matters. It is the official responsibility of the institution to provide the required guidance, clarifications and advices to the students and parents strictly based on the prevailing academic regulations.
R4.4	The SFA shall arrange separate or combined meetings with advisors; course faculty, Parents and students as and when required and discuss the academic progress of students under their advisory group. The Senior Faculty Advisor/ Faculty Advisor shall also offer guidance and help to solve the issues on academic and non-academic matters including personal issues of the students in their advisory group. Advisory meetings shall preferably be convened: 1. Immediately after the commencement of the semester. 2. Immediately after announcing the marks of first internal evaluation test. The internal marks, activity points earned during the semester and eligibility of attendance shall be uploaded in the University portal only after displaying the same in the department notice board at least for two working days. This is for the information and feed back of the students. Any concerns raised by the students regarding attendance and internal marks and activity points shall be looked into in the combined meetings of advisors, course faculty and the students concerned. The principal/ HoD shall ensure the proper redressal of the concerns raised by the students regarding internal assessment and attendance. The FA/SFA shall be the custodian of the minutes and action taken reports of the advisory meetings.

R4.5	The SFA shall get the minutes and action taken reports of advisory meetings approved by the Head of Department and the Principal. It shall be the duty of the HoD and the Principal to produce it before the University as and when required.
R4.6	The FA/SFA shall keep a hard copy of the consolidated statement of attendance, activity points and internal marks of the students in their advisory group. It shall be kept with the HoD without fail for all sorts of inspections.
R4.7	Regular communication with the parents of students in respect of progress in academic matters and other general issues shall be the responsibility of the Senior Faculty Advisor/ Faculty Advisor.
R4.8	The Principal shall inform/forward all regulations, guide lines, communications, announcements etc issued by the University regarding student academic and other matters to the HoDs/ Senior Faculty Advisors for information and timely action.
R4.9	It shall be the official responsibility of the Principal to arrange necessary orientation programmes to the HoDs, SFAs and SAs regarding student counseling, the prevailing University norms, regulations, guidelines and procedures on all academic and other University related matters.
5. Academic Auditing of affiliated institutions.	
R5.1	There shall be academic auditing in each affiliated college at stipulated intervals. The academic auditing shall be conducted jointly by an Internal Quality Assurance Cell (IQAC) within the college and external academic auditor(s) appointed by the University. The Internal Quality Assurance Cell (IQAC) in each college shall oversee and monitor all the academic activities including all internal evaluations and examinations. This cell shall prepare academic audit statements in the formats prescribed by the University for each semester at regular intervals. These reports shall be presented to the external academic auditor(s), who shall use it as reference for independent auditing. The external auditor(s) shall submit the final audit report to the University in the prescribed format. Academic auditing shall cover:- 1. Course delivery and adherence to the course plan, syllabus coverage, quality of question papers used for internal examinations, internal evaluation, maintenance of laboratory experimental set ups and equipments, practical assignments, mini projects and conduct of practical classes and their evaluation. 2. Co-curricular and Extra-curricular activities available for students, the monitoring mechanism of activity points to be earned by the students. 3. Academic functioning of the college encompassing students, faculty and college administration covering punctuality, attendance, discipline, academic, environment, learning ecosystem, academic accountability, academic achievements and benchmarking. 4. The audit shall also cover the quality criteria prescribed by NBA/NAAC.

6. Assessment

R6.1	There shall be End Semester Examinations (ESE) in every semester for all courses as prescribed under the respective curriculum, except the Lab/ workshops courses for 1 & 2 semesters. The End Semester Examinations shall be conducted by the University. Semester classes shall be completed at least ten days before the commencement of the End Semester Examination.
R6.2	The End Semester Examinations (ESE) shall be held twice in a year – May/June session (for even semesters) and November/December session (for odd semesters). However, the End Semester Examinations of the VII and VIII Semesters shall be conducted in both the sessions.
R6.3	Candidates in each semester shall be evaluated both by Continuous Internal Evaluation (CIE) and End Semester Examinations (ESE). The ratio of Continuous Internal Evaluation (CIE) to End Semester Examinations (ESE) shall be as below : 1. Theory Courses : 1 : 2 2. Laboratory Courses : 1 : 1 3. Project : CIE only 4. Seminar : CIE only
R6.4	Continuous Internal Evaluation (CIE)): The Continuous Internal Evaluation shall be on the basis of the day-to-day work, periodic tests (minimum two in a semester) and assignments (minimum two). The faculty member (s) concerned shall carry out the Continuous Internal Evaluation (CIE) for the course allotted to him/her. The CIE marks for individual subjects shall be computed by giving weightage to the following parameters unless otherwise specified in the curriculum.

Course	Attendance	Tests	Assignment/ Class work/ Course project.
Theory	20%	50%	30%
Drawing/ Practical	20%	40%	40%

There shall be minimum two internal evaluation tests, each of 2hrs duration. Each test shall cover 50% of the syllabus and shall be for 50marks. Retest shall be permitted to the students who could not appear for the internal tests due to genuine grounds. Three days shall be utilised for conducting the internal evaluation test.

Project work	a. Work assessed by the project guide – 30% b. Three member Continuous Internal Evaluation Committee – 40% (Guide shall be one member in the CIE committee) c. Final Evaluation by a three member Committee comprising of the department project coordinator, guide and an external expert. The external expert shall be an academician or from industry. The industry expert is preferred : 30% d. One third of the project credit shall be completed in VII semester and two third in VIII semester.

Seminar	The report and the presentation shall be evaluated by a team of internal members comprising three senior faculty members based on the style of presentation, technical content, adequacy of reference, depth of knowledge and overall quality of the report. a) Attendance : 10% b) Guide : 20% c) Technical content : 30% d) Presentation : 40%

	The CIE marks for the attendance (20%) for each theory, practical and drawing shall be awarded in full, only if the candidate has secured 90% attendance or above in the subject. If a student has attendance for a subject below 90%, reduction in the marks for the attendance shall be made proportionally. The CIE marks obtained by the student for all subjects in a semester are to be published at least 5 days before the commencement of the University examinations. Duty leave shall be accounted for awarding the internal marks for attendance.
R6.5	Students, who have completed a course but could not write the end semester examination, shall be awarded “I” Grade, provided they meet other eligibility criteria (R6.6). They shall register (exam registration) and appear for the end semester examination at the next opportunity and earn the credits without having to register (course registration) for the course again.
R6.6	The main eligibility criteria for registering to the End Semester Examination are attendance in the course and no pending disciplinary action. The minimum attendance for appearing for the End Semester Examination is 75% in each course. Students who do not meet these eligibility criteria are awarded an FE grade.
R6.7	The students with FE grade shall register for the courses during the normal semesters in which the courses are offered. However, for the seventh and eighth semester FE grade students can register for the courses in the next immediate chance, if offered by their institute.
R6.8	A student who does not register for all the courses listed in the curriculum for a semester shall not be eligible to enroll for the next higher semester.
R6.9	The maximum number of credits a student can register (course registration) for, in a semester is limited to 08 credits in excess of the total mandatory credits allotted in the curriculum for that semester.
R6.10	A student will be eligible for the award of B. Tech. Degree of the University on satisfying the following requirements: 1. Fulfilled all the curriculum requirements within the stipulated duration of the course. 2. Earned the required minimum credits as specified in the curriculum for the branch of study (R3.6 and R3.7). 3. No pending disciplinary action.

R6.11	Students registered for a course have to attend the course regularly and undergo the Continuous Internal Evaluation (CIE) and appear for the End Semester Examinations (ESE). Credits for the course are deemed to be earned only on getting at least a pass grade ‘P’ or better in the composite evaluation.
R6.12	Pass minimum for a course shall be 40% for the End Semester Examination and 50% of CIE and ESA put together. Letter grade ‘F’ will be awarded to the student for a course if either his/her mark for the End Semester Examination (ESE) is below 40 % or the overall mark [Continuous Internal Evaluation (CIE) + End Semester Examination (ESE)] is below 50 %.
R6.13	Students who received F grade in an End Semester Examination shall have to appear for the End Semester Examination at the next opportunity and earn the credits. They shall not be permitted to register for the course again.
R6.14	Continuous Internal Evaluation mark percentage shall not exceed 30% over the End Semester Examination mark %. CIE marks awarded to a student shall be normalised accordingly. For example if the end semester mark % is 40, then the maximum eligible CIE mark % is 40+30 = 70 %.)
R6.15	Grading is based on the overall % marks obtained by the student in a course, as given in 6.16. The grade card shall only give the grades against the courses the student has registered. Semester grade card shall give the grade for each registered course, Semester Grade Point Average (SGPA) for the semester as well as Cumulative Grade Point Average (CGPA).
R6.16	

Grade and Grade Points

Grades	Grade Point (GP)	% of Total Marks obtained in the course
S	10	90% and above
A+	9.0	85% and above but less than 90%
A	8.5	80% and above but less than 85%
B+	8.0	75% and above but less than 80%
B	7.5	70% and above but less than 75%
C +	7.0	65% and above but less than 70%
C	6.5	60% and above but less than 65%
D	6.0	55% and above but less than 60%
P (Pass)	5.5	50% and above but less than 55%
F (Fail)	0	Below 50% (CIE + ESE) or Below 40 % for ESE
FE	0	Failed due to lack of eligibility criteria (R6.6)
I	0	Could not appear for the end semester examination but fulfills the eligibility criteria.

Classification of B. Tech Degree.	First Class with Distinction	CGPA 8.0 and above
	First Class	CGPA 6.5 and above

Equivalent percentage mark shall be = 10 * CGPA – 2.5

R6.17	**Minimum Cumulative Credit Requirements for Registering to Higher Semesters**

Semester	Allotted Credits	Cumulative Credits	Minimum Cumulative Credits required for B. Tech	Minimum Cumulative Credits required for B. Tech Lateral Enrty.
First	17	17	Not Applicable	Not Applicable
Second	21	38	Not Insisted	Not Insisted
Third	22	60	Not Insisted	Not Insisted
Fourth	22	82	Not Insisted	Not Insisted
Fifth	23	105	21 Credits from S1& S2	Not Insisted
Sixth	24	129	Not Insisted	Not Insisted
Seventh	15	144	47 Credits from S1 to S4	09 Credits from S3 to S4
Eight	16	160	Not Insisted	Not Insisted

R6.18	There is no provision for improving the grade. However, the student is permitted to check the answer books of the End Semester Examination after the results are declared, on payment of the prescribed fee. Any discrepancy in evaluation could be brought to the notice of the Controller of Examination, who shall initiate appropriate action as per the University Examination Manual.
R.6.19	The students can apply for revaluation of the answer books of the end semester examination after the results are declared. The final mark awarded will be the better of the two marks. If the difference in marks obtained in revaluation and the original valuation is more than 15% of the maximum marks, it shall be sent for third valuation. The final mark shall then be the average of the closer of the two marks obtained in the three valuations to the advantage of the student or the mark obtained in the original valuation whichever is higher. The Controller of Examination shall examine such cases and conduct proper enquiry to see whether any of the examiners is responsible for negligent valuation of answer script and initiate suitable action as per the University Examination Manual.
R6.20	Grade cards shall be made available in the student login for the registered courses, in every semester. On earning the required credits for the degree, the University will issue the final consolidated grade sheet for the B. Tech program including CGPA.
R6.21	**Calculation of SGPA/CGPA**
	Semester Grade Point Average (SGPA) and Cumulative Grade Point Average (CGPA) are calculated as follows. SGPA = $\Sigma(Ci\times GPi)/\Sigma Ci$, where ‘Ci’ is the credit assigned for a course and ‘GPi’ is the grade point for that course. Summation is done for all courses specified in the curriculum of that semester. The failed and incomplete courses shall also be considered in the calculation. CGPA = $\Sigma(Ci\times GPi)/\Sigma Ci$, where ‘Ci’ is the credit assigned for a course and ‘GPi’ is the grade point for that course. Summation is done for all courses specified in the

	curriculum up to that semester for which the 'CGPA' is needed. Here the failed courses shall also be accounted. CGPA for the B. Tech programme is arrived at by considering all course credits that are needed for the degree and their respective grade points. For students admitted under lateral entry scheme, credits for the first and second semester courses shall not be accounted for the calculation of CGPA. Equivalent percentage mark shall be = 10 * CGPA – 2.5
R6.22	Any act of violation of University directions, indiscipline, misbehavior, or unfair practice in examinations from the part of students, faculty members, staff, institution, management or any other source shall be viewed very seriously. It is the legal responsibility of the principal and the college management to see that the examinations are conducted strictly as per the directions of the University and as specified in the examination Manual. Malpractices in examinations observed or reported by an official employed by the University, faculty member, invigilator or anybody shall be immediately reported to the Principal. The principal shall in turn conduct a preliminary enquiry giving the student concerned a chance to explain his/her case. The Principal shall then forward the case with his/her preliminary enquiry report and remarks to the Controller of Examinations along with all related documents and evidences within two working days. The Controller of examination shall decide the course of action on the issue as per the prescribed norms in the University Examination Manual.
R6.23	A student shall earn 2 credits by actively involving in co – curricular and extra – curricular activities as per the guidelines issued by the University from time to time. On getting minimum 100 activity points the student passes the course and earns the two credits which shall not be counted for the calculation of CGPA but mandatory for the award of the Degree. For the students admitted under lateral entry scheme the 2 credits shall be considered to be earned on getting 75 activity points. The students are required to keep a file containing documentary proofs of activities done by him/her attested by the Senior Faculty Advisor/ Faculty Advisor.
7. Break of Study	
R7.1	A student is permitted to avail break of study: i) In case of accident or serious illness needing prolonged hospitalization and rest. ii) In case the student has a bright idea and would like to initiate a start-up venture or develop a product. iii) In case of any personal reasons that need a break in study. iv) For internship leading to employment. For break of study due to illness, student shall submit all necessary medical reports together with the recommendation of the doctor treating him giving definite reasons for break of study and its duration. Before joining back, the student should submit the fitness certificate from the doctor who treated him. Students who want to initiate a start-up venture or a product development, have to

	submit a project report, clearly indicating the purpose, action plan, technical details, funding details and future plans to the college Principal. The Principal shall evaluate the proposal by constituting an expert team consisting of a technocrat and a bank executive and take an appropriate decision based on the team's recommendation. The break of study for the start up shall be permitted only after the 4th semester for a maximum duration of two semesters. This is however permitted only on successfully completing the courses listed out in the first two semesters. Students who require a break in study due to personal reasons shall convince the Principal on the genuine need for it by giving authentic evidence for the same. Students who require break in study for 'internship leading to employment' shall produce the offer letter obtained from the employer concerned. The principal shall verify the authenticity of the offer and submit his recommendation to the University sufficiently in advance for approval. Only campus placed students with an annual compensation more than 6 lakhs are eligible to avail this facility. In the semester system followed by the University, break of study for an academic year is the preferred option than break of study for a semester. The student can avail the break of study only with the prior approval of the University. The Principal shall upload the request of the student with all relevant documents to the University portal for the approval with his/her recommendations. Students shall have to rejoin on the first working day of the same semester on which he/she had started availing the break of study.
8.Attendance	
R8.1	Students are expected to attain 100% attendance for all courses. However, under unavoidable circumstances they are permitted to avail leave. Total leave of absence shall not exceed 25% of the academic contact hours for a course and 75% attendance is mandatory for registering to the end semester examination. On medical ground the college Principal can relax the minimum attendance requirement to 60%, to write the end semester examination. This is permitted for one or more courses registered in the semester. Principal shall keep all records which led to his decision on attendance, for verification by the Academic Auditors/ University officials. This provision is applicable only to any two semesters during the entire program period. In case of prolonged illness, break of study is permitted as per R7.1.
R8.2	The Principals are authorized to grant attendance relaxation (duty leave) to the students in officially sponsored national level competitions/championships/ tournaments when called upon to do so, up to a maximum of 10%. Such students should produce the participation certificate countersigned by the University Sports Coordinator/ the Director of Physical Education in the case of sports activities and the Senior Faculty Advisor in the case of other extracurricular activities: within ten days of the event. The participation certificate thus produced shall be forwarded to the Principal with the due recommendation of the respective Head of the Department. Under any circumstances, the principal shall not consider the certificate if the overall attendance of the candidate is less than 60%. Late applications received shall not be considered on any account. The student shall get official prior permission from the University for representing the University.

8.3	The Principals are authorized to grant attendance relaxation (duty leave) to the students for organizing extra/ co-curricular activities, up to a maximum of 05%. Such students should produce the required documents countersigned by the University Sports Coordinator/ the Director of Physical Education in the case of sports activities and the Senior Faculty Advisor in the case of other extra/ co-curricular activities: within ten days of the events. The documents thus produced shall be forwarded to the Principal with the due recommendation of the respective Head of the Department. Under any circumstances, the principal shall not consider the documents, if the overall attendance of the candidate is less than 60%. Late applications received shall not be considered on any account.
9.Inter College Transfer	
R9.1	Inter college transfer shall be applicable only for regular B. Tech students.
R9.2	The transfer shall be permitted just before the commencement of third semester.
R9.3	The transfer shall be with effect from the first working day of the third semester.
R9.4	The transfer shall be only within the sanctioned strength of the receiving college.
R9.5	The following Category of students shall not be eligible for inter college transfer 1. Govt. of India Nominee. 2. Management Quota in Aided colleges. 3. Management Quota in private Self Financing Colleges 4. Students admitted under NRI/PIO quota. 5. Lateral Entry students. 6. Students admitted under TFW Scheme. 7. Students admitted in any supernumerary seats. 8. Any other category which are ineligible as per the conditions for admission prescribed by Govt. of Kerala/Govt. of India.
R9.6	The transfer shall be permitted: 1. Between Govt/ Govt. Aided Colleges. 2. Between Self – Financing Colleges. (Including Govt. Controlled SFC).
R9.7	Notification inviting application for inter college transfer shall be issued by the University just before the commencement of the third semester.
R9.8	The candidate should fulfill the academic eligibility requirement for promotion to the third semester.
R9.9	If the number of applicants is more than the vacant seats available, the transfer may be based on the Kerala Engineering Entrance Rank.
R9.10	The students shall opt only one college for inter college transfer.
R9.11	The selected candidates shall remit a fee of Rs 3000/- (No fee for SC/ST students) within the stipulated date to the University. However, this rule is not applicable to the students transferred to other institutes under “Shift College” University order.
R9.12	The College transfer once approved by the receiving college will be final and binding on the applicant. No student will be permitted, under any circumstances, to refuse the change of college once offered.

10.Migration from other Universities	
R10.1	Migration to the University from other Universities shall be permitted only if the parent University and the APJ Abdul Kalam Technological University enters into a bipartite agreement/ MoU for this purpose. However, this condition is not applicable to the students in any of the Engineering colleges/ institutions, which, before the commencement of KTU Act remained affiliated to Universities except Deemed to be Universities in the State of Kerala.
R10.2	The student shall be permitted to migrate only if he/she fulfills the University eligibility criteria for admission to the course applied for migration.
R10.3	The migration shall be permitted only up to the fifth semester of the B. Tech program and half the duration of the program in the case of other programs.
R10.4	The admission shall be offered on migration basis through lateral transfer of credits. Lateral credit transfer shall be as recommended by the concerned Board of Studies.
R10.5	The students shall be allowed to migrate to the University subject to satisfying the rules and regulations of the University as regards to, maximum number of backlogs, grade points, minimum credit requirement for promotion to higher semesters, etc.
R10.6	The student shall be offered admission in any of the affiliated colleges/institutions of the University subject to availability of seats. The student shall produce no objection certificate from the concerned college/institute in this regard.
R10.7	The students offered admission shall have to take transitory courses/ additional courses of the previous semesters to satisfy the program requirement as recommended by the concerned board of studies.
R10.8	The students offered admission shall pay the migration fees and the University fees as prescribed by the University. The application processing fee (University fee) shall be Rs 5000/- (Rupees five thousand only) and the migration fees shall be Rs 20000/- (Rupees twenty thousand only). The migration fee is charged for the meeting expenses of the concerned Board of studies to decide on the student suitability for migration and to recommend the transitory courses/ additional courses to be done by the student to fulfill the academic requirement of the University. The processing fee shall be paid along with the application, and the migration fee shall be paid to the University at the time of offering admission. The fee once paid shall not be refunded under any circumstances. The students in any of the Engineering colleges / institutions, which, before the commencement of KTU Act remained affiliated to Universities except Deemed to be Universities in the State of Kerala, are exempted from paying the processing fee and the migration fee.
R10.9	The migrated students shall follow the rules and regulations of the University.
R10.10	The students offered admission shall produce a migration certificate from the parent University at the time of admission.
R10.11	The student offered admission shall produce a character certificate from the parent institute/University at the time of admission.
R10.12	Regulations, Scheme and Syllabus of the respective specialization attested by the Registrar of the parent University or equivalent authority shall be submitted to the University along with the application seeking migration to the University.
R10.13	Attested copies of all certificates and mark lists from 10^{th} onwards shall be submitted along with the application for migration (Original certificates and mark lists shall be

	produced as and when required by the University).
R10.14	Assessment of the student suitability for migration in terms of programs, backlogs, grade points, credit requirements, etc shall be done by the concerned Board of Studies.
R10.15	Assessment of the transitory courses/ additional courses to be done by the student as per the academic requirement of the University shall be as recommended by the concerned Board of Studies.
11. Minor in Engineering.	
R11.1	All B. Tech students shall be eligible to register for Minor in Engineering.
R11.2	The Minor in Engineering registration shall be along with the registration of the 3rd semester.
R11.3	If a student fails in any course of the minor, he/she shall not be eligible to continue the B.Tech Minor. However, the additional credits and grades thus far earned by the student shall be included in the grade card but shall not be considered in calculating the CGPA.
R11.4	The student shall earn additional 20 credits to be eligible for the award of B. Tech Degree with Minor.
R11.5	Out of the 20 Credits, 12 credits shall be earned by undergoing a minimum of three courses, during the specified period. The total number of contact hours for these three courses shall be 126 Hrs (42Hrs/course). The duration of a course shall be minimum 14 weeks. The remaining 8 credits could be acquired through two MOOCs recommended by the Board of studies and approved by the Academic Council.
R11.6	Curriculum and the syllabus of the three courses shall be approved by the Board of studies and the Academic Council.
R11.7	The assessment of the courses other than MOOCs and earning of credits shall be as per R6.1 to R6.23. The assessment and certification of the MOOCs shall be as per the prescribed norms of the MOOCs. The candidate shall produce the certification issued by the MOOCs conducting agency in proof of credit attainment.
R11.8	Under graduate Degree with minor shall be issued by the University to the students who fulfill all the academic eligibility requirements for the B. Tech program and Minor in Engineering.
12. B. Tech (Honours)	
R12.1	All B. Tech students are eligible to register B.Tech (Honours). However, their mandatory CGPA at the end of eighth semester shall be 8.5 or higher to be eligible for the award of B. Tech (Honours).
R12.2	The B. Tech (Honours) registration shall be along with the registration of the 4th semester.
R12.3	If a student fails in any course including the course chosen for B. Tech (Honours), he/she shall not be eligible to continue the B.Tech(Honours). However, the additional credits thus far earned by the student shall be included in the grade card but shall not be considered in calculating the CGPA.
R12.4	The student shall earn additional 20 credits to be eligible for the award of B. Tech (Honours) Degree.

R12.5	Out of the 20 Credits, 12 credits shall be earned by undergoing minimum three specified B. Tech (Honours) Elective courses of the respective stream. Credits for the B. Tech (Honours) Elective courses are deemed to be earned only on getting at least a grade 'C' or better in the composite evaluation. A student shall not be permitted to select the normal elective courses of the respective B. Tech programs for attaining the credit requirements of B. Tech (Honours). The remaining 8 credits could be acquired through two MOOCs of the respective streams recommended by the Board of studies and approved by the Academic Council.
R12.6	The assessment and certification of the MOOCs shall be as per the prescribed norms of the MOOCs. The candidate shall produce the certification issued by the MOOCs conducting agency in proof of credit attainment.
R12.7	The institutions offering B. Tech Honours programs shall not charge any additional fee from the students.
R12.8	B. Tech (Honours) Degree shall be issued by the University to the students who fulfill all the academic eligibility requirements for the B. Tech and B. Tech (Honours) programs.
	13. Grace Marks for Sports /Arts Competitions.
R13.1	Only bona-fide, regular candidates are eligible for the award of Grace Marks.
R13.2	The criterion for the award of Grace Marks is representing the University in officially sponsored national level competitions/championships/ tournaments when called upon to do so. The student shall get official prior permission from the University for representing the University.
R13.3	The maximum grace marks that can be awarded to a candidate in a particular semester for all activities put together shall be 5% of the aggregate maximum End Semester Examination marks of all theory courses for which the University conducts End Semester Examinations.
R13.4	The maximum grace marks that can be awarded to a student for a theory course in a particular semester for all activities put together shall not exceed 10% of the maximum aggregate marks of End Semester Examination of the course.
R13.5	The Grace Marks shall not be awarded to a student for Practical/ Lab/ Viva Voce/ internal assessment/ Seminar etc even though she/he fails for the same.
R13.6	Eligible Grace Marks shall be distributed equally on all theory papers/courses of an examination. However, re – distribution of Grace Marks shall be allowed only in the case of those courses of an examination for which the candidate has passed. Re-distribution is possible from passed courses to failed courses only. Re-distribution of Grace Marks is not permissible from failed courses to other courses for a pass.
R13.7	The Grace Marks shall be awarded for all theory papers/courses/subjects in a semester.
R13.8	Re- distribution shall be done only for enabling a candidate to obtain the minimum marks required for a pass.
R13.09	Grace Marks shall not be re – distributed from one semester to another semester.
R13.10	If the candidate does not secure the minimum marks required for a pass even after effecting re- distribution, eligible moderation fixed by the respective board if any, shall be awarded to that candidate in addition to the Grace Marks for a pass.
R13.11	Eligible Grace Marks shall be awarded for the regular examination of the performing semester only. Grace Marks shall not be awarded for supplementary examinations.

R13.12	The performing semester shall be considered from 1st July to 31st December (Odd semester) and 1st January to 30th June (Even Semester).
R13.13	Grace Marks shall be awarded on the basis of performance in the respective semester.
R13.14	The request for Grace Marks shall be submitted to the Controller of Examinations through the principal along with all relevant documents, within the time limit prescribed by the University. The request for Grace Marks received after the time limit shall not be entertained on any account.
R13.15	Only a single highest achievement during the period of a semester shall be considered for awarding the grace marks.
14.Grace Marks for Persons With Disability (PWD)	
R14.1	A person with disability means a person suffering from not less than 40% of any disability as certified by the District Medical Board. To be eligible for the grace marks, the certificate of disability specifying the percentage of disability shall be produced before the Principal at the time of admission.
R14.2	The Grace Marks that can be awarded for PWD candidates shall be 25% of the marks scored by the candidate in each course at the time of finalization of the results.
R14.3	Transfer of marks from one paper to another shall not be permitted. Fractions of marks if any, while computing the Grace Marks shall be rounded off to the next higher integer.
R14.4	PWD candidates who are eligible for Grace Marks shall be awarded Grace Marks for regular and supplementary chances until they pass the whole examination.
R14.5	Grace Marks shall be awarded only for the marks of the End Semester Examinations conducted by the University.
R14.6	The request for Grace Marks shall be submitted to the Controller of Examinations through the principal along with all relevant documents, within the time limit prescribed by the University. The request for Grace Marks received after the time limit shall not be entertained on any account.
15. Transitory provision.	
15.1	Notwithstanding anything contained in these regulations, the Vice-Chancellor shall, for a period of two years from the date of coming into force of these regulations, has the power to provide by order that these Regulations shall be applied to any B. Tech program with such modifications as may be necessary.

CURRICULUM I TO VIII: B. TECH MECHANICAL ENGINEERING

Every course of B. Tech. Program shall be placed in one of the nine categories as listed in table below.

Sl. No	Category	Code	Credits
1	Humanities and Social Sciences including Management courses	HMC	8
2	Basic Science courses	BSC	26
3	Engineering Science Courses	ESC	22
4	Program Core Courses	PCC	76
5	Program Elective Courses	PEC	15
6	Open Elective Courses	OEC	3
7	Project work and Seminar	PWS	10
8	Mandatory Non-credit Courses (P/F) with grade	MNC	-----
9	Mandatory Student Activities (P/F)	MSA	2
	Total Mandatory Credits	**162**	
10	Value Added Course (Optional)	VAC	20

No semester shall have more than six lecture-based courses and two laboratory and/or drawing/seminar/project courses in the curriculum. Semester-wise credit distribution shall be as below:

Sem	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Total**
Credits	17	21	22	22	23	23	15	17	160
Activity Points	50				50				---
Credits for Activity	2								2
G.Total									**162**

Basic Science Courses: Maths, Physics, Chemistry, Biology for Engineers, Life Science etc

Engineering science courses: Basic Electrical, Engineering Graphics, Programming, Workshop, Basic Electronics, Basic Civil, Engineering Mechanics, Mechanical Engineering, Thermodynamics, , Design Engineering, Materials Engineering etc.

Humanities and Social Sciences including Management courses: English, Humanities, Professional Communication, Management, Finance & Accounting, Life Skills, Professional Communication, Economics etc.

Mandatory non-credit courses: Sustainable Engineering, Constitution of India/Essence of Indian Knowledge Tradition, Industrial Safety Engineering, disaster management etc.

Course Code and Course Number

Each course is denoted by a unique code consisting of three alphabets followed by three numerals like **E C L 2 0 1.** The first two letter code refers to the department offering the course. EC stands for course in Electronics & Communication, course code MA refers to a course in Mathematics, course code ES refers to a course in Engineering Science etc. Third letter stands for the nature of the course as indicated in the Table 1.

Table 1: Code for the courses

Code	Description
T	Theory based courses (other the lecture hours, these courses can have tutorial and practical hours, e.g., L-T-P structures 3-0-0, 3-1-2, 3-0-2 etc.)
L	Laboratory based courses (where performance is evaluated primarily on the basis of practical or laboratory work with LTP structures like 0-0-3, 1-0-3, 0-1-3 etc.)
N	Non-credit courses
D	Project based courses (Major, Mini Projects)
Q	Seminar Courses

Course Number is a three digit number and the first digit refers to the Academic year in which the course is normally offered, i.e. 1, 2, 3, or 4 for the B. Tech. Programme of four year duration. Of the other two digits, the last digit identifies whether the course is offered normally in the odd (odd number), even (even number) or in both the semesters (zero). The middle number could be any digit. ECL 201 is a laboratory course offered in EC department for third semester, MAT 101 is a course in Mathematics offered in the first semester, EET 344 is a course in Electrical Engineering offered in the sixth semester, PHT 110 is a course in Physics offered both the first and second semesters, EST 102 is a course in Basic Engineering offered by one or many departments. These course numbers are to be given in the curriculum and syllabi.

Departments

Each course is offered by a Department and their two-letter course prefix is given in Table 2

Table 2: Departments and their codes

SL NO	Department	Course Prefix	SL NO	Department	Course Prefix
1	Aeronautical Engg	AO	20	Food Technology	FT
2	Applied Electronics & Instrumentation	AE	21	Humanities	HU
3	Artificial Intelligence	AI	22	Industrial Engg	IE
4	Artificial Intelligence & Data Science	AD	23	Information Technology	IT
5	Automobile	AU	24	Instrumentation & Control	IC
6	Biomedical Engg	BM	25	Mandatory Courses	MC
7	Biotechnology	BT	26	Mathematics	MA
8	Chemical Engg	CH	27	Mechanical Engg	ME
9	Chemistry	CY	28	Mechatronics	MR
10	Civil Engg	CE	29	Metallurgy	MT
11	Computer Science	CS	30	Mechanical (Auto)	MU
12	Computer Science (Artificial Intelligence)	CA	31	Mechanical (Prod)	MP
13	Computer Science (Artificial Intelligence & Machine Learning)	CM	32	Naval & Ship Building	SB
14	Computer Science (Data Science)	CD	33	Physics	PH
15	Computer Science Cyber Security	CC	34	Polymer Engg	PO
16	Electronics & Biomedical	EB	35	Production Engg	PE
17	Electronics & Communication	EC	36	Robotics and Automation	RA
18	Electrical and Computer Engineering	EO	37	Safety & Fire Engg	FS
19	Electrical & Electronics	EE			

SEMESTER I

SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
A	MAT 101	LINEAR ALGEBRA AND CALCULUS	3-1-0	4	4
B 1/2	PHT 110	ENGINEERING PHYSICS	3-1-0	4	4
	CYT 100	ENGINEERING CHEMISTRY	3-1-0	4	4
C 1/2	EST 100	ENGINEERING MECHANICS	2-1-0	3	3
	EST 110	ENGINEERING GRAPHICS	2-0-2	4	3
D 1/2	EST 120	BASICS OF CIVIL & MECHANICAL ENGINEERING	4-0-0	4	4
	EST 130	BASICS OF ELECTRICAL & ELECTRONICS ENGINEERING	4-0-0	4	4
E	HUN 101	LIFE SKILLS	2-0-2	4	--
S 1/2	PHL 120	ENGINEERING PHYSICS LAB	0-0-2	2	1
	CYL 120	ENGINEERING CHEMISTRY LAB	0-0-2	2	1
T 1/2	ESL 120	CIVIL & MECHANICAL WORKSHOP	0-0-2	2	1
	ESL 130	ELECTRICAL & ELECTRONICS WORKSHOP	0-0-2	2	1
TOTAL				**23/24 ***	**17**

*Minimum hours per week

NOTE:

To make up for the hours lost due to induction program, one extra hour may be allotted to each course

SEMESTER II

SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
A	MAT 102	VECTOR CALCULUS, DIFFERENTIAL EQUATIONS AND TRANSFORMS	3-1-0	4	4
B 1/2	PHT 110	ENGINEERING PHYSICS B	3-1-0	4	4
	CYT 100	ENGINEERING CHEMISTRY	3-1-0	4	4
C 1/2	EST 100	ENGINEERING MECHANICS	2-1-0	3	3
	EST 110	ENGINEERING GRAPHICS	2-0-2	4	3
D 1/2	EST 120	BASICS OF CIVIL & MECHANICAL ENGINEERING	4-0-0	4	4
	EST 130	BASICS OF ELECTRICAL & ELECTRONICS ENGINEERING	4-0-0	4	4
E	HUN 102	PROFESSIONAL COMMUNICATION	2-0-2	4	--
F	EST 102	PROGRAMMING IN C	2-1-2	5	4
S 1/2	PHL 120	ENGINEERING PHYSICS LAB	0-0-2	2	1
	CYL 120	ENGINEERING CHEMISTRY LAB	0-0-2	2	1
T 1/2	ESL 120	CIVIL & MECHANICAL WORKSHOP	0-0-2	2	1
	ESL 130	ELECTRICAL & ELECTRONICS WORKSHOP	0-0-2	2	1
TOTAL				**28/29**	**21**

NOTE:

1. Engineering Physics B and Engineering Chemistry shall be offered in both semesters. Institutions can advise students belonging to about 50% of the number of branches in the Institution to opt for Engineering Physics B in SI and Engineering Chemistry in S2 & vice versa. Students opting for Engineering Physics B in a semester should attend Physics Lab in the same semester and students opting for Engineering Chemistry in one semester should attend Engineering Chemistry Lab in the same semester.

2. Engineering Mechanics and Engineering Graphics shall be offered in both semesters. Institutions can advise students belonging to about 50% of the number of branches in the Institution to opt for Engineering Mechanics in SI and Engineering Graphics in S2 & vice versa.

3. Basics of Civil & Mechanical Engineering and Basics of Electrical & Electronics Engineering shall be offered in both semesters. Basics of Civil & Mechanical Engineering contain equal weightage for Civil Engineering and Mechanical Engineering. Slot for the course is D with CIE marks of 25 each and ESE marks of 50 each. Students belonging to branches of AEI, EI, BME, ECE, EEE, ICE, CSE, IT, RA can choose this course in S1.

Basics of Electrical & Electronics Engineering contain equal weightage for Electrical Engineering and Electronics Engineering. Slot for the course is D with CIE marks of 25 each and ESE marks of 50 each. Students belonging to AERO, AUTO, CE, FSE, IE, ME, MECHATRONICS, PE, METTULURGY, BT, BCE, CHEM, FT, POLY can choose this course in S1. Students having Basics of Civil & Mechanical Engineering in one semester should attend Civil & Mechanical Workshop in the same semester and students having Basics of Electrical & Electronics Engineering in a semester should attend Electrical & Electronics Workshop in the same semester.

4. LIFE SKILLS

Life skills are those competencies that provide the means for an individual to be resourceful and positive while taking on life's vicissitudes. Development of one's personality by being aware of the self, connecting with others, reflecting on the abstract and the concrete, leading and generating change, and staying rooted in time-tested values and principles is being aimed at. This course is designed to enhance the employability and maximize the potential of the students by introducing them to the principles that underlie personal and professional success, and help them acquire the skills needed to apply these principles in their lives and careers.

5. PROFESSIONAL COMMUNICATION

Objective is to develop in the under-graduate students of engineering a level of competence in English required for independent and effective communication for their professional needs. Coverage: Listening, Barriers to listening, Steps to overcome them, Purposive listening practice, Use of technology in the professional world. Speaking, Fluency & accuracy in speech, Positive thinking, Improving self-expression, Tonal variations, Group discussion practice, Reading, Speed reading practice, Use of extensive readers, Analytical and critical reading practice, Writing Professional Correspondence, Formal and informal letters, Tone in formal writing, Introduction to reports. Study Skills, Use of dictionary, thesaurus etc., Importance of contents page, cover & back pages, Bibliography, Language Lab.

SEMESTER III

SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
A	MAT201	PARTIAL DIFFERENTIAL EQUATION AND COMPLEX ANALYSIS	3-1-0	4	4
B	MET201	MECHANICS OF SOLIDS	3-1-0	4	4
C	MET203	MECHANICS OF FLUIDS	3-1-0	4	4
D	MET205	METALLURGY & MATERIAL SCIENCE	3-1-0	4	4
E 1/2	EST200	DESIGN AND ENGINEERING	2-0-0	2	2
	HUT200	PROFESSIONAL ETHICS	2-0-0	2	2
F	MCN201	SUSTAINABLE ENGINEERING	2-0-0	2	--
S	MEL201	COMPUTER AIDED MACHINE DRAWING	0-0-3	3	2
T	MEL203	MATERIALS TESTING LAB	0-0-3	3	2
R/M	VAC	REMEDIAL/MINOR COURSE	3-1-0	4**	4
TOTAL				**26/30**	**22/26**

NOTE:

1. Design & Engineering and Professional Ethics shall be offered in both S3 and S4. Institutions can advise students belonging to about 50% of the number of branches in the Institution to opt for Design & Engineering in S3 and Professional Ethics in S4 & vice versa.
2. *All Institutions shall keep 4 hours exclusively for Remedial class/Minor course (Thursdays from 3 to 5 PM and Fridays from 2 to 4 PM). If a student does not opt for minor programme, he/she can be given remedial class.

SEMESTER IV

SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
A	MAT202	PROBABILITY, STATISTICS AND NUMERICAL METHODS	3-1-0	4	4
B	MET202	ENGINEERING THERMODYNAMICS	3-1-0	4	4
C	MET204	MANUFACTURING PROCESS	3-1-0	4	4
D	MET206	FLUID MACHINERY	3-1-0	4	4
E 1/2	EST200	DESIGN AND ENGINEERING	2-0-0	2	2
	HUT200	PROFESSIONAL ETHICS	2-0-0	2	2
F	MCN202	CONSTITUTION OF INDIA	2-0-0	2	--
S	MEL202	FM & HM LAB	0-0-3	3	2
T	MEL204	MACHINE TOOLS LAB-I	0-0-3	3	2
R/M/H	VAC	REMEDIAL/MINOR/HONORS COURSE	3-1-0	4*	4
		TOTAL		**26/30**	**22/26**

NOTE:

1. Design & Engineering and Professional Ethics shall be offered in both S3 and S4. Institutions can advise students belonging to about 50% of the number of branches in the Institution to opt for Design & Engineering in S3 and Professional Ethics in S4 & vice versa.
2. *All Institutions should keep 4 hours exclusively for Remedial class/Minor course (Thursdays from 3 to 5 PM and Fridays from 2 to 4 PM). If a student does not opt for minor programme, he/she can be given remedial class.

SEMESTER V

SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
A	MET301	MECHANICS OF MACHINERY	3-1-0	4	4
B	MET303	THERMAL ENGINEERING	3-1-0	4	4
C	MET305	INDUSTRIAL & SYSTEMS ENGINEERING	3-1-0	4	4
D	MET307	MACHINE TOOLS AND METROLOGY	3-1-0	4	4
E 1/2	HUT300	INDUSTRIAL ECONOMICS AND FOREIGN TRADE	3-0-0	3	3
	HUT310	MANAGEMENT FOR ENGINEERS	3-0-0	3	3
F	MCN301	DISASTER MANAGEMENT	2-0-0	2	--
S	MEL331	MACHINE TOOLS LAB-II	0-0-3	3	2
T	MEL333	THERMAL ENGINEERING LAB-I	0-0-3	3	2
R/M/H	VAC	REMEDIAL/MINOR/HONORS COURSE	3-1-0	4*	4
TOTAL				**27/31**	**23/27**

NOTE:

1. Industrial Economics & Foreign Trade and Management for Engineers shall be offered in both S5 and S6. Institutions can advise students belonging to about 50% of the number of branches in the Institution to opt for Industrial Economics & Foreign Trade in S5 and Management for Engineers in S6 and vice versa.
2. *All Institutions should keep 4 hours exclusively for Remedial class/Minor/Honours course (Tuesdays from 3 to 5 PM and Wednesdays from 3 to 5 PM). If a student does not opt for minor/honours programme, he/she can be given remedial class.

SEMESTER VI

SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
A	MET302	HEAT & MASS TRANSFER	3-1-0	4	4
B	MET304	DYNAMICS AND DESIGN OF MACHINERY	3-1-0	4	4
C	MET306	ADVANCED MANUFACTURING ENGINEERING	3-1-0	4	4
D	METXXX	PROGRAM ELECTIVE I	2-1-0	3	3
E ½	HUT300	INDUSTRIAL ECONOMICS AND FOREIGN TRADE	3-0-0	3	3
	HUT310	MANAGEMENT FOR ENGINEERS	3-0-0	3	3
F	MET308	COMPREHENSIVE COURSE WORK	1-0-0	1	1
S	MEL332	COMPUTER AIDED DESIGN & ANALYSIS LAB	0-0-3	3	2
T	MEL334	THERMAL ENGINEERING LAB-II	0-0-3	3	2
R/M/H	VAC	REMEDIAL/MINOR/HONOURS COURSE	3-1-0	4*	4
		TOTAL		**25/29**	**23/27**

PROGRAM ELECTIVE I

SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
D	MET312	NONDESTRUCTIVE TESTING	2-1-0	3	3
	MET322	COMPUTATIONAL FLUID DYNAMICS	2-1-0		
	MET332	ADVANCED MECHANICS OF SOLIDS	2-1-0		
	MET342	IC ENGINE COMBUSTION AND POLLUTION	2-1-0		
	MET352	AUTOMOBILE ENGINEERING	2-1-0		
	MET362	PRODUCT DESIGN AND DEVELOPMENT	2-1-0		
	MET372	ADVANCED METAL JOINING TECHNIQUES	2-1-0		

NOTE:

1. Industrial Economics & Foreign Trade and Management for Engineers shall be offered in both S5 and S6. Institutions can advise students belonging to about 50% of the number of branches in the Institution to opt for Industrial Economics & Foreign Trade in S5 and Management for Engineers in S6 and vice versa.

2. **All Institutions should keep 4 hours exclusively for Remedial class/Minor/Honours course (Tuesdays from 2 to 4 PM and Wednesdays from 2 to 4 PM). If a student does not opt for minor/honors programme, he/she can be given remedial class.

3. Comprehensive Course Work: The comprehensive course work in the sixth semester of study shall have a written test of 50 marks. The written examination will be of objective type similar to the GATE examination and will be conducted online by the University. **Syllabus for comprehensive examination shall be prepared by the respective BoS choosing any 5 core courses studied from semester 3 to 5.** The pass minimum for this course is 25. The course should be mapped with a faculty and classes shall be arranged for practising questions based on the core courses listed in the curriculum.

SEMESTER VII

SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
A	MET401	DESIGN OF MACHINE ELEMENTS	2-1-0	3	3
B	METXXX	PROGRAM ELECTIVE II	2-1-0	3	3
C	METXXX	OPEN ELECTIVE	2-1-0	3	3
D	MCN401	INDUSTRIAL SAFETY ENGINEERING	2-1-0	3	---
S	MEL411	MECHANICAL ENGINEERING LAB	0-0-3	3	2
T	MEQ413	SEMINAR	0-0-3	3	2
U	MED415	PROJECT PHASE I	0-0-6	6	2
R/M/H	VAC	REMEDIAL/MINOR/HONORS COURSE	3-1-0	4*	4
TOTAL				**24/28**	**15/19**

PROGRAM ELECTIVE II

SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
B	MET413	ADVANCED METHODS IN NONDESTRUCTIVE TESTING	2-1-0	3	3
	MET423	OPTIMIZATION TECHNIQUES AND APPLICATIONS	2-1-0		
	MET433	FINITE ELEMENT METHOD	2-1-0		
	MET443	AEROSPACE ENGINEERING	2-1-0		
	MET453	HYBRID AND ELECTRIC VEHICLES	2-1-0		
	MET463	OPERATIONS MANAGEMENT	2-1-0		
	MET473	AIR CONDITIONING AND REFRIGERATION	2-1-0		

OPEN ELECTIVE

The open elective is offered in semester 7. Each program should specify the courses (maximum 5) they would like to offer as electives for other programs The courses listed below are offered by the **Department of MECHANICAL ENGINEERING for students of other undergraduate branches offered in the college under KTU.**

SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
C	MET415	INTRODUCTION TO BUSINESS ANALYTICS	2-1-0	3	3
	MET425	QUANTITATIVE TECHNIQUES FOR ENGINEERS	2-1-0		
	MET435	AUTOMOTIVE TECHNOLOGY	2-1-0		
	MET445	RENEWABLE ENERGY ENGINEERING	2-1-0		
	MET455	QUALITY ENGINEERING AND MANAGEMENT	2-1-0		

NOTE:

1. *All Institutions should keep 4 hours exclusively for Remedial class/Minor/Honors course (Mondays from 10 to 12 and Wednesdays from 10 to 12 Noon). If a student does not opt for minor/honours programme, he/she can be given remedial class.
2. Seminar: To encourage and motivate the students to read and collect recent and reliable information from their area of interest confined to the relevant discipline from technical publications including peer reviewed journals, conference, books, project reports etc., prepare a report based on a central theme and present it before a peer audience. Each student shall present the seminar for about 20 minutes duration on the selected topic. The report and the presentation shall be evaluated by a team of internal members comprising three senior faculty members based on style of presentation, technical content, adequacy of references, depth of knowledge and overall quality of the report.

Total marks: 100, only CIE, minimum required to pass 50

Attendance	10
Guide	20
Technical Content of the Report	30
Presentation	40

3. Project Phase I: A Project topic must be selected either from research literature or the students themselves may propose suitable topics in consultation with their guides. The object of Project Work I is to enable the student to take up investigative study in the broad field of Mechanical Engineering, either fully theoretical/practical or involving both theoretical and practical work to be assigned by the Department on a group of three/four students, under the guidance of a Supervisor. This is expected to provide a good initiation for the student(s) in R&D work. The assignment to normally include:
   - Survey and study of published literature on the assigned topic;
   - Preparing an Action Plan for conducting the investigation, including team work;
   - Working out a preliminary Approach to the Problem relating to the assigned topic;
   - Block level design documentation
   - Conducting preliminary Analysis/ Modelling/ Simulation/ Experiment/ Design/

Feasibility;

- Preparing a Written Report on the Study conducted for presentation to the Department;
- Final Seminar, as oral Presentation before the evaluation committee.

Total marks: 100, only CIE, minimum required to pass 50

Guide	30
Interim evaluation by the evaluation committee	20
Final Seminar	30
The report evaluated by the evaluation committee	20

The evaluation committee comprises HoD or a senior faculty member, Project coordinator and project supervisor.

SEMESTER VIII

SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
A	MET402	MECHATRONICS	2-1-0	3	3
B	METXXX	PROGRAM ELECTIVE III	2-1-0	3	3
C	METXXX	PROGRAM ELECTIVE IV	2-1-0	3	3
D	METXXX	PROGRAM ELECTIVE V	2-1-0	3	3
E	MET404	COMPREHENSIVE VIVA VOCE	1-0-0	1	1
U	MED416	PROJECT PHASE II	0-0-12	12	4
R/M/H	VAC	REMEDIAL/MINOR/HONORS COURSE	3-1-0	4*	4
		TOTAL		**25/28**	**17/21**

PROGRAM ELECTIVE III

SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
B	MET414	QUALITY MANAGEMENT	2-1-0	3	3
	MET424	DECISIONS WITH METAHEURISTICS	2-1-0		
	MET434	PRESSURE VESSEL AND PIPING DESIGN	2-1-0		
	MET444	DATA ANALYTICS FOR ENGINEERS	2-1-0		
	MET454	INDUSTRIAL TRIBOLOGY	2-1-0		
	MET464	MICRO AND NANO MANUFACTURING	2-1-0		
	MET474	HEATING AND VENTILATION SYSTEMS	2-1-0		

PROGRAM ELECTIVE IV

SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
C	MET 416	COMPOSITE MATERIALS	2-1-0	3	3
	MET 426	ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING	2-1-0		
	MET 436	ACOUSTICS AND NOISE CONTROL	2-1-0		
	MET 446	HEAT TRANSFER EQUIPMENT DESIGN	2-1-0		
	MET 456	ROBOTICS AND AUTOMATION	2-1-0		
	MET 466	TECHNOLOGY MANAGEMENT	2-1-0		
	MET 476	CRYOGENIC ENGINEERING	2-1-0		

PROGRAM ELECTIVE V

SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
D	MET 418	RELIABILITY ENGINEERING	2-1-0	3	3
	MET 428	INDUSTRIAL INTERNET OF THINGS	2-1-0		
	MET438	FRACTURE MECHANICS	2-1-0		
	MET 448	GAS TURBINES AND JET PROPULSION	2-1-0		
	MET 458	ADVANCED ENERGY ENGINEERING	2-1-0		
	MET 468	ADDITIVE MANUFACTURING	2-1-0		
	MET 478	POWER PLANT ENGINEERING	2-1-0		

NOTE

1. *All Institutions should keep 4 hours exclusively for Remedial class/Minor/Honours course (Mondays from 10 to 12 and Wednesdays from 10 to 12). If a student does not opt for minor/honors programme, he/she can be given remedial class.
2. Comprehensive Course Viva: The comprehensive course viva in the eighth semester of study shall have a viva voce for 50 marks. The viva voce shall be conducted based on the syllabus mentioned for comprehensive course work in the sixth semester. The viva voce will be conducted by the same three member committee assigned for final project phase II evaluation towards the end of the semester. The pass minimum for this course is 25. The course should be mapped with a faculty and classes shall be arranged for practising questions based on the core courses listed in the curriculum. The mark will be treated as internal and should be uploaded along with internal marks of other courses.
3. **Project Phase II:** The object of Project Work II & Dissertation is to enable the student to extend further the investigative study taken up in Project 1, either fully theoretical/practical or involving both theoretical and practical work, under the guidance of a Supervisor from the Department alone or jointly with a Supervisor drawn from R&D laboratory/Industry. This is expected to provide a good training for the student(s) in R&D work and technical leadership. The assignment to normally include:
    - In depth study of the topic assigned in the light of the Report prepared under PhaseI;
    - Review and finalization of the Approach to the Problem relating to the assigned topic;
    - Detailed Analysis/ Modelling/ Simulation/ Design/ Problem Solving/ Experiment as needed;
    - Final development of product/process, testing, results, conclusions and future directions;
    - Preparing a paper for Conference presentation/Publication in Journals, if possible;

- Preparing a Dissertation in the standard format for being evaluated by the Department;
- Final Presentation before a Committee

Total marks: 150, only CIE, minimum required to pass 75

Guide	30
Interim evaluation, 2 times in the semester by the evaluation committee	50
Quality of the report evaluated by the above committee	30
Final evaluation by a three member committee	40

(The final evaluation committee comprises Project coordinator, expert from Industry/research Institute and a senior faculty from a sister department. The same committee will conduct comprehensive course viva for 50 marks).

MINOR

Minor is an additional credential a student may earn if s/he does 20 credits worth of additional learning in a discipline other than her/his major discipline of B.Tech. degree. The objective is to permit a student to customize their Engineering degree to suit their specific interests. Upon completion of an Engineering Minor, a student will be better equipped to perform interdisciplinary research and will be better employable. Engineering Minors allow a student to gain interdisciplinary experience and exposure to concepts and perspectives that may not be a part of their major degree programs.

The academic units offering minors in their discipline will prescribe the set of courses and/or other activities like projects necessary for earning a minor in that discipline. A specialist basket of 3-6 courses is identified for each Minor. Each basket may rest on one or more foundation courses. A basket may have sequences within it, i.e., advanced courses may rest on basic courses in the basket. S/he accumulates credits by registering for the required courses, and if the requirements for a particular minor are met within the time limit for the course, the minor will be awarded. This will be mentioned in the Degree Certificate as “Bachelor of Technology in xxx with Minor in yyy”. The fact will also be reflected in the consolidated grade card, along with the list of courses taken. If one specified course cannot be earned during the course of the programme, that minor will not be awarded. The individual course credits earned, however, will be reflected in the consolidated grade card.

(i) The curriculum/syllabus committee/BoS shall prepare syllabus for courses to be included in the curriculum from third to eight semesters for all branches. The minor courses shall be identified by **M slot courses.**

(ii) Registration is permitted for Minor at the beginning of third semester. Total credits required is 182 (162 + 20 credits from value added courses)

(iii) Out of the 20 Credits, 12 credits shall be earned by undergoing a minimum of three courses listed in the curriculum for minor, of which one course shall be a mini project based on the chosen area. They can do miniproject either in S7 or in S8. The remaining 8 credits could be acquired by undergoing 2 MOOCs recommended by the Board of studies and approved by the Academic Council or through courses listed in the curriculum. The classes for Minor shall be conducted along with regular classes and no extra time shall be required for conducting the courses.

(iv) There won't be any supplementary examination for the courses chosen for Minor.

(v) On completion of the program, "Bachelor of Technology in xxx with Minor in yyy" will be awarded.

(vi) The registration for minor program will commence from semester 3 and the all academic units offering minors in their discipline should prescribe set of such courses. The courses shall be grouped into maximum of 3 baskets. The basket of courses may have sequences within it, i.e., advanced courses may rest on basic courses in the basket. Reshuffling of courses between various baskets will not be allowed. In any case, they should carry out a mini project based on the chosen area in S7 or S8. Students who have registered **for B.Tech Minor in MECHANICAL ENGINEERING Branch** can opt to study the courses listed below:

Semester	BASKET I				BASKET II				BASKET III			
	Course No.	Course Name	HOURS	CREDIT	Course No.	Course Name	HOURS	CREDIT	Course No.	Course Name	HOURS	CREDIT
S3	MET281	MECHANICS OF MATERIALS	4	4	MET283	FLUID MECHANICS & MACHINERY	4	4	MET285	MATERIAL SCIENCE & TECHNOLOGY	4	4
S4	MET282	THEORY OF MACHINES	4	4	MET284	THERMODYNAMICS	4	4	MET286	MANUFACTURING TECHNOLOGY	4	4
S5	MET381	DYNAMICS OF MACHINES	4	4	MET383	THERMAL SCIENCE AND ENGINEERING	4	4	MET385	MACHINE TOOLS ENGINEERING	4	4
S6	MET382	MACHINE DESIGN	4	4	MET384	HEAT TRANSFER	4	4	MET386	INDUSTRIAL ENGINEERING	4	4
S7	MED481	MINIPROJECT	4	4	MED481	MINIPROJECT	4	4	MED481	MINIPROJECT	4	4
S8	MED482	MINIPROJECT	4	4	MED482	MINIPROJECT	4	4	MED482	MINIPROJECT	4	4

HONOURS

Honours is an additional credential a student may earn if s/he opts for the extra 20 credits needed for this in her/his own discipline. Honours is not indicative of class. KTU is providing this option for academically extra brilliant students to acquire Honours. Honours is intended for a student to gain expertise/specialise in an area inside his/her major B.Tech discipline and to enrich knowledge in emerging/advanced areas in the branch of engineering concerned. It is particularly suited for students aiming to pursue higher studies. Upon completion of Honours, a student will be better equipped to perform research in her/his branch of engineering. On successful accumulation of credits at the end of the programme, this will be mentioned in the Degree Certificate as "Bachelor of Technology in xxx, with Honours." The fact will also be reflected in the consolidated grade card, along with the list of courses taken. If one specified course cannot be earned during the course of the programme, Honours will not be awarded. The individual course credits earned, however, will be reflected in the consolidated grade card.

The courses shall be grouped into maximum of 3 groups, each group representing a particular specialization in the branch. The students shall select only the courses from same group in all semesters. It means that the specialization is to be fixed by the student and cannot be changed subsequently. The internal evaluation, examination and grading shall be exactly as for other mandatory courses. The Honours courses shall be identified by H slot courses.

(i) The curriculum/syllabus committee/BOS shall prepare syllabus for courses to be included in the curriculum from fourth to eight semesters for all branches. The honours courses shall be identified by H slot courses.

(ii) Registration is permitted for Honours at the beginning of fourth semester. Total credits required is 182 (162 + 20 credits from value added courses).

(iii) Out of the 20 Credits, 12 credits shall be earned by undergoing a minimum of three courses listed in the curriculum for honours, of which one course shall be a mini project based on the chosen area. The remaining 8 credits could be acquired by undergoing 2 MOOCs recommended by the Board of studies and approved by the Academic Council or through courses listed in the curriculum. The classes for Honours shall be conducted along with regular classes and no extra time shall be required for conducting the courses. The students should earn a grade of 'C' or better for all courses under honours.

(iv) There won't be any supplementary examination for the courses chosen for honours.

(v) On successful accumulation of credits at the end of the programme, "Bachelor of Technology in xxx, with Honours" will be awarded if overall CGPA is greater than or equal to 8.5, earned a grade of 'C' or better for all courses chosen for honours and without any history of 'F' Grade.

(vi) The registration for honours program will commence from semester 4 and the all academic units offering honours in their discipline should prescribe set of such courses. The courses shall be grouped into maximum of 3 groups, each group representing a particular specialization in the branch. The students shall select only the courses from same group in all semesters. It means that the specialization is to be fixed by the student and cannot be changed subsequently. In any case, they should carry out a mini project based on the chosen area in S8. Students who have registered for **B.Tech Honours in MECHANICAL ENGINEERING** can opt to study the courses listed below.

SEMESTER	GROUP I				GROUP II				GROUP III			
	Course No.	**Course Name**	**HOURS**	**CREDIT**	**Course No.**	**Course Name**	**HOURS**	**CREDIT**	**Course No.**	**Course Name**	**HOURS**	**CREDIT**
S4	MET292	CONTINUUM MECHANICS	4	4	MET294	ADVANCED MECHANICS OF FLUIDS	4	4	MET296	MATERIALS IN MANUFACTURING	4	4
S5	MET393	EXPERIMENTAL STRESS	4	4	MET395	ADVANCED THERMODYNA	4	4	MET397	FLUID POWER	4	4

		ANALYSIS				MICS				AUTOMATION		
S6	MET394	ADVANCED DESIGN SYNTHESIS	4	4	MET396	COMPRESSIBL E FLUID FLOW	4	4	MET398	ADVANCED NUMERICAL CONTROLLED MACHINING	4	4
S7	MET495	ADVANCED THEORY OF VIBRATIONS	4	4	MET497	COMPUTATIO NAL METHODS IN FLUID FLOW & HEAT TRANSFER	4	4	MET499	PRECISION MACHINING	4	4
S8	MED496	MINIPROJEC T	4	4	MED496	MINIPROJECT	4	4	MED496	MINIPROJECT	4	4

INDUCTION PROGRAM

There will be three weeks induction program for first semester students. It is a unique three-week immersion Foundation Programme designed especially for the fresher's which includes a wide range of activities right from workshops, lectures and seminars to sports tournaments, social work and much more. The programme is designed to mould students into well-rounded individuals, aware and sensitized to local and global conditions and foster their creativity, inculcate values and ethics, and help students to discover their passion. Foundation Programme also serves as a platform for the fresher's to interact with their batchmates and seniors and start working as a team with them. The program is structured around the following five themes:

The programme is designed keeping in mind the following objectives:

- **Values and Ethics**: Focus on fostering a strong sense of ethical judgment and moral fortitude.
- **Creativity**: Provide channels to exhibit and develop individual creativity by expressing themselves through art, craft, music, singing, media, dramatics, and other creative activities.
- **Leadership, Communication and Teamwork**: Develop a culture of teamwork and group communication.
- **Social Awareness**: Nurture a deeper understanding of the local and global world and our place in at as concerned citizens of the world.

SEMESTER -1&2

MAT 101	LINEAR ALGEBRA AND CALCULUS	CATEGORY	L	T	P	CREDIT	Year of Introduction
		BSC	3	1	0	4	2019

Preamble: This course introduces students to some basic mathematical ideas and tools which are at the core of any engineering course. A brief course in Linear Algebra familiarises students with some basic techniques in matrix theory which are essential for analysing linear systems. The calculus of functions of one or more variables taught in this course are useful in modelling and analysing physical phenomena involving continuous change of variables or parameters and have applications across all branches of engineering.

Prerequisite: A basic course in one-variable calculus and matrix theory**.**

Course Outcomes: After the completion of the course the student will be able to

CO 1	solve systems of linear equations, diagonalize matrices and characterise quadratic forms
CO 2	compute the partial and total derivatives and maxima and minima of multivariable functions
CO 3	compute multiple integrals and apply them to find areas and volumes of geometrical shapes, mass and centre of gravity of plane laminas
CO 4	perform various tests to determine whether a given series is convergent, absolutely convergent or conditionally convergent
CO 5	determine the Taylor and Fourier series expansion of functions and learn their applications.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3	3	3	2	1			1	2		2
CO 2	3	3	3	3	2	1			1	2		2
CO 3	3	3	3	3	2	1			1	2		2
CO 4	3	2	3	2	1	1			1	2		2
CO 5	3	3	3	3	2	1			1	2		2

Assessment Pattern

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination (Marks)**
	Test 1 (Marks)	**Test 2 (Marks)**	
Remember	10	10	20
Understand	20	20	40
Apply	20	20	40
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE marks	ESE marks	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

Assignments: Assignment should include specific problems highlighting the applications of the methods introduced in this course in science and engineering.

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1): Solve systems of linear equations, diagonalize matrices and characterise quadratic forms

1. A is a real matrix of order $3 \times 3$and $X = \begin{bmatrix} x \\ y \\ z \end{bmatrix}$. What can you say about the solution of $AX = 0$if rank of A is 1? 2 ?3?

2. Given$A = \begin{bmatrix} 3 & 0 & 2 \\ 0 & 2 & 0 \\ -2 & 0 & 0 \end{bmatrix}$, find an orthogonal matrix Pthat diagonalizes A.

3. Find out what type of conic section the following quadratic form represents

$$17x^2 - 30x_1x_2 + 17x_2^2 = 128$$

4. The matrix $A = \begin{bmatrix} -2 & 2 & -3 \\ 2 & 1 & -6 \\ -1 & -2 & 0 \end{bmatrix}$has an eigen value5 with corresponding Eigen vector$X = \begin{bmatrix} 1 \\ 2 \\ -1 \end{bmatrix}$. Find A^5X

Course Outcome 2 (CO2): compute the partial and total derivatives and maxima and minima of multivariable functions

1. Find the slope of the surface $z = x^2y + 5y^3$in the x-direction at the point (1,-2)

2. Given the function $w = xy + z$, use chain rule to find the instantaneous rate of change of $w$at each point along the curve $x = cost, y = sint, z = t$

3. Determine the dimension of rectangular box open at the top , having a volume 32 cubic ft and requiring the least amount of material for it's construction.

Course Outcome 3(CO3): compute multiple integrals and apply them to find areas and volumes of geometrical shapes, mass and centre of gravity of plane laminas.

1. Evaluate $\iint_D (x + 2y)\, DA$where D is the region bounded by the parabolas $y = 2x^2$and $y = 1 + x^2$

2. Explain how you would find the volume under the surface $z = f(x, y)$and over a specific region Din the xyplane using (i) double integral (ii) triple integral?

3. Find the mass and centre of gravity of a triangular lamina with vertices (0,0), (2,1), (0,3) if the density function is $f(x, y) = x + y$

4. Use spherical coordinates to evaluate $\iiint_B (x^2 + y^2 + z^2)^3\, dV$where B is the unit ball defined by $B = \{(x, y, z): x^2 + y^2 + z^2 \leq 1\}$

Course Outcome 4 (CO4): perform various tests to determine whether a given series is convergent, absolutely convergent or conditionally convergent.

1. What is the difference between a sequence and a series and when do you say that they are convergent? Divergent?

2. Determine whether the series $\sum_{n=1}^{n=\infty} \frac{5}{2n^2+4n+3}$converges or diverges.

3. Is the series $\sum_{n=1}^{n=\infty} \frac{(-1)^{n-1}}{n}$convergent? Absolutely convergent? Conditionally convergent?

Course Outcome 5 (CO5): determine the Taylor and Fourier series expansion of functions and learn their applications.

1. Assuming the possibility of expansion find the Maclaurin series expansion of

   $f(x) = (1 + x)^k$for$|x| < 1$where $k$is any real number. What happens if $k$is a positive

   integer?

2. Use Maclaurin series of $ln(1 + x), -1 < x \leq 1$to find an approximate value of$ln2$.

3. Find the Fourier series of the function$f(x) = x^2, -2 \leq x < 2, f(x + 4) = f(x)$. Hence using Parseval's identity prove that $1 + \frac{1}{2^4} + \frac{1}{3^4} + \ldots = \frac{\pi^4}{90}$

4. Expand the function $f(x) = x\ (0 < x < 1/2)$ into a (i) Fourier sine series (ii) Fourier cosine series.

Model Question paper

QP CODE: PAGES:3

Reg No:________________

Name :________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY FIRST SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: **MAT 101**

Max. Marks: 100 **Duration: 3 Hours**

LINEAR ALGEBRA AND CALCULUs

(2019-Scheme)

(Common to all branches)

PART A

(Answer **all** questions, **each** question carries 3 marks)

1. Determine the rank of the matrix $A = \begin{bmatrix} 1 & 2 & -1 \\ -2 & -4 & 2 \\ 3 & 6 & -3 \end{bmatrix}$.
2. Write down the eigen values of $= \begin{bmatrix} 2 & 0 \\ 0 & -1 \end{bmatrix}$. What are the eigen values of $P^{-1}AP$ where $P = \begin{bmatrix} -4 & 2 \\ 3 & -1 \end{bmatrix}$?
3. Find $f_x(1,3)$ and $f_y(1,3)$ for the function $f(x,y) = 2x^3y^2 + 2y + 4x$.
4. Show that the function $u(x,t) = \sin(x - ct)$ is a solution of the equation $\frac{6^2u}{6t^2} = c^2\frac{6^2u}{6x^2}$.
5. Use double integral to find the area of the region enclosed between the parabolas $y = \frac{1}{2}x^2$ and the line $y = 2x$.
6. Use polar coordinates to evaluate the area of the region bounded by $x^2 + y^2 = 4$, the line $y = x$ and the y axis in the first quadrant
7. Test the convergence of the series $\sum_{k=1}^{\infty}\frac{k}{k+1}$.
8. Test the convergence of the alternating series $\sum_{k=1}^{\infty}(-1)^{k+1}\frac{1}{k}$ using Leibnitz test.
9. Find the Taylor series expansion of $sin\pi x$ about $x = \frac{1}{2}$
10. Find the values to which the Fourier series of

    $f(x) = x$ for $-\pi < x < \pi$, with $f(x + 2\pi) = f(x)$ converges (10x3=30)

PART B

(Answer **one full** question from each module, each question carries **14** marks)

Module -I

11. (a) Solve the following system of equations

$$y + z - 2w = 0$$
$$2x - 3y - 3z + 6w = 2$$
$$4x + y + z - 2w = 4$$

(b) Find the eigen values and eigen vectors of the matrix $\begin{bmatrix} -2 & 2 & -3 \\ 2 & 1 & -6 \\ -1 & -2 & 0 \end{bmatrix}$

12. (a) Diagonalize the matrix $\begin{bmatrix} -1 & 2 & -2 \\ 2 & 4 & 1 \\ 2 & 1 & 4 \end{bmatrix}$

(b) What kind of conic section the quadratic form $3x_1^2 + 22x_1x_2 + 3x_2^2 = 0$ represents? Transform it to principal axes.

Module - II

13. (a) Find the local linear approximation to $f(x, y) = \sqrt{x^2 + y^2}$ at the point $(3, 4)$.Use it to approximate $f(3.04, 3.98)$

(b) Let $w = \sqrt{x^2 + y^2 + z^2}$, $x = cos\theta, y = sin\theta, z = tan\theta$. Use chain rule to find $\frac{dw}{d\theta}$ when $\theta = \frac{\pi}{4}$.

14. (a) Let $z = f(x, y)$ where $x = rcos\theta, y = rsin\theta$, prove that $\left(\frac{6z}{6x}\right)^2 + \left(\frac{6z}{6y}\right)^2 = \left(\frac{6z}{6r}\right)^2 + \frac{1}{r^2}\left(\frac{6z}{6\theta}\right)^2$.

(b) Locate all relative maxima, relative minima and saddle points $f(x, y) = xy + \frac{a^3}{x} + \frac{b^3}{y} (a \neq 0, b \neq 0)$.

Module - III

15. (a) Evaluate $\iint_D (2x^2y + 9y^3)\, dxdy$ where D is the region bounded by $y = \frac{2}{3}x$ and $y = 2\sqrt{x}$

(b) Evaluate $\int_0^4 \int_{\sqrt{y}}^2 e^{x^3}\, dxdy$ changing the order of integration.

16. (a) Find the volume of the solid bounded by the cylinder $x^2 + y^2 = 4$ and the planes $y + z = 4$ and $z = 0$..

(b) Evaluate $\iiint \sqrt{1 - x^2 - y^2 - z^2}\, dxdydz$, taken throughout the volume of the sphere $x^2 + y^2 + z^2 = 1$, by transforming to spherical polar coordinates

Module - IV

17. (a) Test the convergence of the series

(i) $\sum_{k=1}^{\infty} \frac{k^k}{k!}$ (ii) $\sum_{k=2}^{\infty} \left(\frac{4k-5}{2k+1}\right)^k$

(b) Determine the convergence or divergence of the series $\sum_{k=1}^{\infty} (-1)^k \frac{(2k-1)!}{3^k}$

18. (a) Check whether the series $\sum_{k=1}^{\infty} (-1)^{k+1} \frac{(2k)!}{(3k-2)!}$ is absolutely convergent, conditionally convergent or divergent.

(b) Test the convergence of the series $1 + \frac{1.2}{1.3} + \frac{1.2.3}{1.3.5} + \frac{1.2.3.4}{1.3.5.7} + \cdots$

Module - V

19. (a) Obtain the Fourier series of for $f(x) = e^{-x}$, in the interval $0 < x < 2\pi$.with $f(x + 2\pi) = f(x)$. Hence deduce the value of $\sum_{n=2}^{\infty} \frac{(-1)^n}{1+n^2}$.

(b) Find the half range sine series of $f(x) = \begin{cases} \frac{2kL}{x} & if\ 0 < x < \frac{L}{2} \\ \frac{2k(L-x)}{L} & if\ \frac{L}{2} < x < L \end{cases}$

20. (a)Expand $(1 + x)^{-2}$.as a Taylor series about $x = 0$and state the region of convergence of the series.

(b) Find the Fourier series for $f(x) = x^2$ in the interval $-\pi < x < \pi$

with $f(x + 2\pi) = f(x)$.Hence show that $\frac{1}{1^4} + \frac{1}{2^4} + \frac{1}{3^4} + \cdots = \frac{\pi^4}{90}$. (14X5=70)

Syllabus

Module 1 (Linear algebra)

(Text 2: Relevant topics from sections 7.3, 7.4, 7.5, 8.1,8.3,8.4)

Systems of linear equations, Solution by Gauss elimination, row echelon form and rank of a matrix, fundamental theorem for linear systems (homogeneous and non-homogeneous, without proof), Eigen values and eigen vectors. Diagonaliztion of matrices, orthogonal transformation, quadratic forms and their canonical forms.

Module 2 (multivariable calculus-Differentiation)

(Text 1: Relevant topics from sections 13.3, 13.4, 13.5, 13.8)

Concept of limit and continuity of functions of two variables, partial derivatives, Differentials, Local Linear approximations, chain rule, total derivative, Relative maxima and minima, Absolute maxima and minima on closed and bounded set.

Module 3(multivariable calculus-Integration)

(Text 1: Relevant topics from sections 14.1, 14.2, 14.3, 14.5, 14.6, 14.8)

Double integrals (Cartesian), reversing the order of integration, Change of coordinates (Cartesian to polar), finding areas and volume using double integrals, mass and centre of gravity of inhomogeneous laminas using double integral. Triple integrals, volume calculated as triple integral, triple integral in cylindrical and spherical coordinates (computations involving spheres, cylinders).

Module 4 (sequences and series)

(Text 1: Relevant topics from sections 9.1, 9.3, 9.4, 9.5, 9.6)

Convergence of sequences and series, convergence of geometric series and p-series(without proof), test of convergence (comparison, ratio and root tests without proof); Alternating series and Leibnitz test, absolute and conditional convergence.

Module 5 (Series representation of functions)

(Text 1: Relevant topics from sections 9.8, 9.9. Text 2: Relevant topics from sections 11.1, 11.2, 11.6)

Taylor series (without proof, assuming the possibility of power series expansion in appropriate domains), Binomial series and series representation of exponential, trigonometric, logarithmic functions (without proofs of convergence); Fourier series, Euler formulas, Convergence of Fourier series (without proof), half range sine and cosine series, Parseval's theorem (without proof).

Text Books

1. H. Anton, I. Biven,S.Davis, "Calculus", Wiley, 10^{th} edition, 2015.
2. Erwin Kreyszig, Advanced Engineering Mathematics, 10^{th}Edition, John Wiley & Sons, 2016.

Reference Books

1. J. Stewart, Essential Calculus, Cengage, 2^{nd} edition, 2017
2. G.B. Thomas and R.L. Finney, Calculus and Analytic geometry, 9 th Edition, Pearson, Reprint, 2002.
3. Peter V. O'Neil, Advanced Engineering Mathematics , Cengage, 7th Edition, 2012
4. Veerarajan T., Engineering Mathematics for first year, Tata McGraw-Hill, New Delhi, 2008.
5. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 36 Edition, 2010.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Linear Algebra (10 hours)**	
1.1	Systems of linear equations, Solution by Gauss elimination	1
1.2	Row echelon form, finding rank from row echelon form, fundamental theorem for linear systems	3
1.3	Eigen values and eigen vectors	2
1.4	Diagonaliztion of matrices, orthogonal transformation, quadratic forms	4

	and their canonical forms.	
2	**Multivariable calculus-Differentiation (8 hours)**	
2.1	Concept of limit and continuity of functions of two variables, partial derivatives	2
2.2	Differentials, Local Linear approximations	2
2.3	Chain rule, total derivative	2
2.4	Maxima and minima	2
3	**Multivariable calculus-Integration (10 hours)**	
3.1	Double integrals (Cartesian)-evaluation	2
3.2	Change of order of integration in double integrals, change of coordinates (Cartesian to polar),	2
3.3	Finding areas and volumes, mass and centre of gravity of plane laminas	3
3.4	Triple integrals	3
4	**Sequences and series (8 hours)**	
4.1	Convergence of sequences and series, geometric and p-series	2
4.2	Test of convergence(comparison, ratio and root)	4
4.3	Alternating series and Leibnitz test, absolute and conditional convergence	2
5	**Series representation of functions (9 hours)**	
5.1	Taylor series, Binomial series and series representation of exponential, trigonometric, logarithmic functions;	3
5.2	Fourier series, Euler formulas, Convergence of Fourier series(Dirichlet's conditions)	3
5.3	Half range sine and cosine series, Parseval's theorem.	3

PHT 110	ENGINEERING PHYSICS B (FOR NON-CIRCUIT BRANCHES)	Category	L	T	P	CREDIT	Year of Introduction
		BSC	3	1	0	4	2019

Preamble: The aim of the Engineering Physics program is to offer students a solid background in the fundamentals of Physics and to impart that knowledge in engineering disciplines. The program is designed to develop scientific attitudes and enable the students to correlate the concepts of Physics with the core programmes

Prerequisite: Higher secondary level Physics, Mathematical course on vector calculus, differential equations and linear algebra

Course Outcomes: After the completion of the course the student will be able to

CO 1	Compute the quantitative aspects of waves and oscillations in engineering systems.
CO 2	Apply the interaction of light with matter through interference, diffraction and identify these phenomena in different natural optical processes and optical instruments.
CO 3	Analyze the behaviour of matter in the atomic and subatomic level through the principles of quantum mechanics to perceive the microscopic processes in electronic devices.
CO 4	Apply the knowledge of ultrasonics in non-destructive testing and use the principles of acoustics to explain the nature and characterization of acoustic design and to provide a safe and healthy environment
CO 5	Apply the comprehended knowledge about laser and fibre optic communication systems in various engineering applications

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	2						1	2			1
CO 2	3	2						1	2			1
CO 3	3	2						1	2			1
CO 4	3							1	2			1
CO 5	3	2						1	2			1

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination (Marks)
	Test 1 (Marks)	Test 2 (Marks)	
Remember	15	15	30
Understand	25	25	50

Apply	10	10	20
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE MARKS	ESE MARKS	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks

Continuous Assessment Test (2 numbers) : 25 marks

Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Explain the effect of damping force on oscillators.
2. Distinguish between transverse and longitudinal waves.
3. (a) Derive an expression for the fundamental frequency of transverse vibration in a stretched string.
   (b) Calculate the fundamental frequency of a string of length 2 m weighing 6 g kept stretched by a load of 600 kg.

Course Outcome 2 (CO2):

1. Explain colours in thin films.
2. Distinguish between Fresnel and Fraunhofer diffraction.
3. (a) Explain the formation of Newton's rings and obtain the expression for radii of bright and dark rings in reflected system. Also explain how it is used to determine the wavelength of a monochromatic source of light.
   (b) A liquid of refractive index μ is introduced between the lens and glass plate. What happens to the fringe system? Justify your answer.

Course Outcome 3 (CO3):

1. Give the physical significance of wave function?

2. What are excitons ?

3. (a) Solve Schrodinger equation for a particle in a one dimensional box and obtain its energy eigen values and normalised wave functions.

   (b) Calculate the first three energy values of an electron in a one dimensional box of width 1 A^0 in electron volt.

Course Outcome 4 (CO4):

1. Explain reverberation and reverberation time.
2. How ultrasonic waves are used in non-destructive testing.
3. (a) With a neat diagram explain how ultrasonic waves are produced by a piezoelectric oscillator.

   (b) Calculate frequency of ultrasonic waves that can be produced by a nickel rod of length 4 cm. (Young's Modulus = 207 G Pa, Density = 8900 Kg /m^3)

Course Outcome 5 (CO 5):

1. Distinguish between spontaneous emission and stimulated emission.
2. Explain optical resonators.
3. (a) Explain the construction and working of Ruby Laser.

   (b) Calculate the numerical aperture and acceptance angle of a fibre with a core refractive index of 1.54 and a cladding refractive index of 1.50 when the fibre is inside water of refractive index 1.33.

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Model Question paper

QP CODE: PAGES:3

Reg No:_______________

Name :_______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY FIRST SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: PHT 110

Course Name: Engineering Physics B

Max.Marks: 100 **Duration: 3 Hours**

PART A

Answer all Questions. Each question carries 3 Marks

1. Compare electrical and mechanical oscillators.

2. Distinguish between longitudinal and transverse waves.

3. Write a short note on antireflection coating.

4. Diffraction of light is not as evident in daily experience as that of sound waves. Give reason.

5. State and explain Heisenberg's Uncertainty principle. With the help of it explain natural line broadening.

6. Explain surface to volume ratio of nanomaterials.

7. Define sound intensity level. Give the values of threshold of hearing and threshold of pain.

8. Describe the method of non-destructive testing using ultra sonic waves

9. Explain the condition of population inversion

10. Distinguish between step index and graded index fibre. (10x3=30)

PART B

Answer any one full question from each module. Each question carries 14 Marks

Module 1

11. (a) Derive the differential equation of damped harmonic oscillator and deduce its solution. Discuss the cases of over damped, critically damped and under damped cases. (10)

(b) The frequency of a tuning fork is 500 Hz and its Q factor is 7×10^{4}. Find the relaxation time. Also calculate the time after which its energy becomes 1/10 of its initial undamped value. (4)

12. (a) Derive an expression for the velocity of propagation of a transverse wave in a stretched string. Deduce laws of transverse vibrations. (10)

(b) The equation of transverse vibration of a stretched string is given by y =0.00327 sin (72.1x-2.72t) m, in which the numerical constants are in S.I units. Evaluate (i) Amplitude (ii) Wavelength (iii) Frequency and (iv) Velocity of the wave. (4)

Module 2

13. (a) Explain the formation of Newton's rings and show that the radius of dark ring is proportional to the square root of natural numbers. How can we use Newton's rings experiment to determine the refractive index of a liquid? (10)

(b) Two pieces of plane glass are placed together with a piece of paper between two at one end. Find the angle of the wedge in seconds if the film is viewed with a monochromatic light of wavelength 4800Å. Given β = 0.0555 cm. (4)

14. (a) Explain the diffraction due to a plane transmission grating. Obtain the grating equation. (10)

(b) A grating has 6000 lines per cm. Find the angular separation of the two yellow lines of mercury of wavelengths 577 nm and 579 nm in the second order. (4)

Module 3

15. (a) Derive time dependent and independent Schrodinger equations. (10)

(b) An electron is confined to one dimensional potential box of length 2Å. Calculate the energies corresponding to the first and second quantum states in eV. (4)

16. (a) Classify nanomaterials based on dimensionality of quantum confinement and explain the following nanostructures. (i) nano sheets (ii) nano wires (iii) quantum dots. (10)

(b) Find the de Broglie wavelength of electron whose kinetic energy is 15 eV. (4)

Module 4

17. (a) Explain reverberation and reverberation time? What is the significance of Reverberation time. Explain the factors affecting the acoustics of a building and their corrective measures? (10)

(b) The volume of a hall is 3000 m^3. It has a total absorption of $100m^2$ sabine. If the hall is filled with audience who add another 80 m^2sabine, then find the difference in reverberation time. (4)

18. (a) With a neat diagram explain how ultrasonic waves are produced by piezoelectric oscillator. Also discuss the piezoelectric method of detection of ultrasonic waves. (10)

(b) An ultrasonic source of 0.09 MHz sends down a pulse towards the sea bed which returns after 0.55 sec. The velocity of sound in sea water is 1800 m/s. Calculate the depth of the sea and the wavelength of the pulse. (4)

Module 5

19. (a) Outline the construction and working of Ruby laser. (8)

(b) What is the principle of holography? How is a hologram recorded? (6)

20. (a) Define numerical aperture of an optic fibre and derive an expression for the NA of a step index fibre with a neat diagram. (10)

(b) An optical fibre made with core of refractive index 1.5 and cladding with a fractional index difference of 0.0006. Find refractive index of cladding and numerical aperture. (4)

(14x5=70)

SYLLABUS

ENGINEERING PHYSICS B (FOR NON-CIRCUIT BRANCHES)

Module 1

Oscillations and Waves

Harmonic oscillations, Damped harmonic motion-Derivation of differential equation and its solution, Over damped, Critically damped and Under damped Cases, Quality factor-Expression, Forced oscillations-Differential Equation-Derivation of expressions for amplitude and phase of forced oscillations, Amplitude Resonance-Expression for Resonant frequency, Quality factor and Sharpness of Resonance, Electrical analogy of mechanical oscillators

Wave motion- Derivation of one dimensional wave equation and its solution, Three dimensional wave equation and its solution (no derivation), Distinction between transverse and longitudinal waves, Transverse vibration in a stretched string, Statement of laws of vibration

Module 2

Wave Optics

Interference of light-Principle of superposition of waves, Theory of thin films - Cosine law (Reflected system), Derivation of the conditions of constructive and destructive Interference, Interference due to wedge shaped films -Determination of thickness and test for optical planeness, Newton's rings - Measurement of wavelength and refractive index, Antireflection coatings

Diffraction of light, Fresnel and Fraunhofer classes of diffraction, Diffraction grating-Grating equation, Rayleigh criterion for limit of resolution, Resolving and Dispersive power of a grating with expression (no derivation)

Module 3

Quantum Mechanics & Nanotechnology

Introduction for the need of Quantum mechanics, Wave nature of Particles, Uncertainty principle, Applications-Absence of electrons inside a nucleus and Natural line broadening Mechanism, Formulation of time dependent and independent Schrodinger wave equations-Physical Meaning of wave function, Particle in a one dimensional box- Derivation for normalised wave function and energy eigen values, Quantum Mechanical Tunnelling (Qualitative)

Introduction to nanoscience and technology, Increase in surface to volume ratio for nanomaterials, Quantum confinement in one dimension, two dimension and three dimension-Nano sheets, Nano wires and Quantum dots, Properties of nanomaterials-mechanical, electrical and optical, Applications of nanotechnology (qualitative ideas)

Module 4

Acoustics & Ultrasonics

Acoustics, Classification of sound-Musical sound-Noise, Characteristics of Musical Sounds-Pitch or frequency-Loudness or Intensity-Measurement of Intensity level-Decibel-Quality or timbre, Absorption coefficient, Reverberation-Reverberation time-Significance- Sabine's formula (no derivation), Factors affecting architectural acoustics and their remedies

Ultrasonics-Production- Magnetostriction effect and Piezoelectric effect, Magnetostriction oscillator and Piezoelectric oscillator –Working, Detection of ultrasonic waves - Thermal and Piezoelectric methods, Ultrasonic diffractometer- Expression for the velocity of ultrasonic waves in a liquid , Applications of ultrasonic waves -SONAR,NDT and Medical

Module 5

Laser and Fibre optics

Properties of laser, Absorption and emission of radiation, Spontaneous and stimulated emission, Einstein's coefficients (no derivation), Population inversion, Metastable states, basic components of laser, Active medium, Pumping mechanism, Optical resonant cavity, working principle, Construction and working of Ruby laser and Helium neon laser ,Construction and working of semiconductor laser(Qualitative) ,Applications of laser, Holography, Difference between hologram and photograph, Recording of hologram and reconstruction of image, Applications

Optic fibre-Principle of propagation of light, Types of fibres-Step index and Graded index fibres, Numerical aperture –Derivation, Fibre optic communication system (block diagram), Industrial, Medical and Technological applications, Fibre optic sensors-Intensity Modulated and Phase modulated sensors

Text Books

1. M.N.Avadhanulu, P.G.Kshirsagar,TVS Arun Murthy "A Text book of Engineering Physics", S.Chand &Co., Revised Edition, 2019.

2. H.K.Malik , A.K. Singh, "Engineering Physics" McGraw Hill Education, Second Edition, 2017.

Reference Books

1. Arthur Beiser, "Concepts of Modern Physics ", Tata McGraw Hill Publications, 6th Edition 2003
2. D.K. Bhattacharya, Poonam Tandon, "Engineering Physics", Oxford University Press, 2015
3. Md.N.Khan & S.Panigrahi "Principles of Engineering Physics 1&2", Cambridge University Press, 2016
4. Aruldhas G., "Engineering Physics", PHI Pvt. Ltd., 2015
5. Ajoy Ghatak, "Optics", Mc Graw Hill Education, Sixth Edition, 2017
6. T. Pradeep, "Nano:The Essentials'', McGraw Hill India Ltd, 2007
7. B. B. Laud, "Lasers and Non linear optics", New age International Publishers, 2nd Edition ,2005
8. Premlet B., "Advanced Engineering Physics", Phasor Books,10th edition ,2017
9. I. Dominic and. A. Nahari, "A Text Book of Engineering physics", Owl Books Publishers, Revised edition, 2016

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Oscillations and Waves (9 hours)**	
1.1	Harmonic oscillations, Damped harmonic motion-Derivation of differential equation and its solution, Over damped, Critically damped and Under damped Cases, Quality factor-Expression	2 hrs
1.2	Forced oscillations-Differential Equation-Derivation of expressions for amplitude and phase of forced oscillations, Amplitude Resonance-Expression for Resonant frequency, Quality factor and Sharpness of Resonance, Electrical analogy of mechanical oscillators	3hrs
1.3	Wave motion- Derivation of one dimensional wave equation and its solution, Three dimensional wave equation and its solution (no derivation)	2 hrs
1.4	Distinction between transverse and longitudinal waves, Transverse vibration in a stretched string, Statement of laws of vibration	2 hrs
2	**Wave Optics (9 hours)**	
2.1	Interference of light-Principle of superposition of waves, Theory of thin films - Cosine law (Reflected system), Derivation of the conditions of constructive and destructive Interference	2 hrs
2.2	Interference due to wedge shaped films -Determination of thickness and test for optical planeness, Newton's rings - Measurement of wavelength and refractive index, Antireflection coatings	4 hrs
2.3	Diffraction of light, Fresnel and Fraunhofer classes of diffraction, Diffraction grating-Grating equation	2 hrs
2.4	Rayleigh criterion for limit of resolution, Resolving and Dispersive power of a grating with expression (no derivation)	1 hr
3	**Quantum Mechanics &Nanotechnology (9hours)**	
3.1	Introduction for the need of Quantum mechanics, Wave nature of Particles, Uncertainty principle, Applications-Absence of electrons inside a nucleus and Natural line broadening mechanism	2 hrs
3.2	Formulation of time dependent and independent Schrodinger wave equations-Physical Meaning of wave function, Particle in a one dimensional box- Derivation for normalised wave function and energy eigen values, Quantum Mechanical Tunnelling (Qualitative)	4 hrs
3.3	Introduction to nanoscience and technology, Increase in surface to volume ratio for nanomaterials, Quantum confinement in one dimension, two dimension and three dimension-Nano sheets, Nano wires and Quantum dots	2 hrs
3.4	Properties of nanomaterials-mechanical, electrical and optical Applications of nanotechnology (qualitative ideas)	1 hr
4	**Acoustics & Ultrasonics (9hrs)**	
4.1	Acoustics, Classification of sound-Musical sound-Noise, Characteristics	3 hrs

	of Musical Sounds-Pitch or frequency-Loudness or Intensity-Measurement of Intensity level-Decibel-Quality or timbre, Absorption coefficient, Reverberation-Reverberation time-Significance- Sabine's formula (no derivation)	
4.2	Factors affecting architectural acoustics and their remedies	1 hr
4.3	Ultrasonics-Production- Magnetostriction effect and Piezoelectric effect, Magnetostriction oscillator and Piezoelectric oscillator – Working, Detection of ultrasonic waves - Thermal and Piezoelectric methods	3hrs
4.4	Ultrasonic diffractometer- Expression for the velocity of ultrasonic waves in a liquid ,Applications of ultrasonic waves -SONAR,NDT and Medical.	2 hr
5	**Laser and Fibre optics (9hours)**	
5.1	Properties of laser, Absorption and emission of radiation, Spontaneous and stimulated emission, Einstein's coefficients (no derivation), Population inversion, Metastable states, basic components of laser, Active medium, Pumping mechanism, Optical resonant cavity, working principle	2 hrs
5.2	Construction and working of Ruby laser and Helium neon laser ,Construction and working of semiconductor laser(Qualitative) Applications of laser	3 hrs
5.3	Holography, Difference between hologram and photograph, Recording of hologram and reconstruction of image, Applications	1 hr
5.4	Optic fibre-Principle of propagation of light, Types of fibres-Step index and Graded index fibres, Numerical aperture –Derivation, Fibre optic communication system (block diagram), Industrial, Medical and Technological applications, Fibre optic sensors-Intensity Modulated and Phase modulated sensors	3 hrs

EST 100	ENGINEERING MECHANICS	CATEGORY	L	T	P	CREDIT	Year of Introduction
		ESC	2	1	0	3	2019

Preamble: Goal of this course is to expose the students to the fundamental concepts of mechanics and enhance their problem-solving skills. It introduces students to the influence of applied force system and the geometrical properties of the rigid bodies while stationary or in motion. After this course students will be able to recognize similar problems in real-world situations and respond accordingly.

Prerequisite: Nil

Course Outcomes: After completion of the course the student will be able to:

CO 1	Recall principles and theorems related to rigid body mechanics
CO 2	Identify and describe the components of system of forces acting on the rigid body
CO 3	Apply the conditions of equilibrium to various practical problems involving different force system.
CO 4	Choose appropriate theorems, principles or formulae to solve problems of mechanics.
CO 5	Solve problems involving rigid bodies, applying the properties of distributed areas and masses

Mapping of course outcomes with program outcomes (Minimum requirement)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	2	2	-	-	-	-	-	-	-	-	-	-
CO 2	3	3	-	-	-	-	-	-	-	-	-	-
CO 3	3	3	-	-	-	-	-	-	-	-	-	-
CO 4	3	3	-	-	-	-	-	-	-	-	-	-
CO 5	3	3	-	-	-	-	-	-	-	-	-	-

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination (Marks)
	Test 1 (Marks)	Test 2 (Marks)	
Remember	10	10	15
Understand	10	10	15
Apply	30	30	70
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE marks	ESE marks	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

<u>End Semester Examination Pattern:</u> There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

<u>Course Level Assessment Questions:</u>

Part A

Course Outcome 1 (CO1): (One question from each module to meet the course objective 1: *To recall principles and theorems related to rigid body mechanics***)**

1. Explain D'Alembert's principle

2. Distinguish static and dynamic friction

3. State and explain perpendicular axis theorem

Course Outcome 2 (CO2) (One question from each module to meet the course objective 2: *To identify and describe the components of system of forces acting on the rigid body***)**

1. A simply supported beam AB of span 5 m is carrying point loads 5 kN, 3 kN and 2 kN at 1m, 3m and 4m respectively from support A. Calculate the support reaction at B.

2. A gymnast holding onto a bar, is suspended motionless in mid-air. The bar is supported by two ropes that attach to the ceiling. Diagram the forces acting on the combination of gymnast and bar

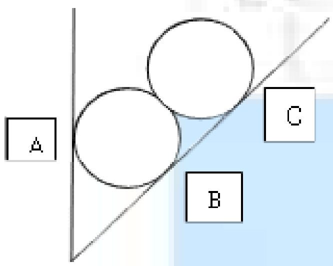
3. While you are riding your bike, you turn a corner following a circular arc. Illustrate the forces that act on your bike to keep you along the circular path ?

Part B

All the questions under this section shall assess the learning levels corresponding to the course outcomes listed below.

CO 3	To apply the conditions of equilibrium to various practical problems involving different force system.
CO 4	To choose appropriate theorems, principles or formulae to solve problems of mechanics.
CO 5	To solve problems involving rigid bodies, applying the properties of distrib ted areas and masses

1. Two rollers each of weight 100 N are supported by an inclined plane and a vertical wall. Find the reaction at the points of contact A, B, C. Assume all the surfaces to be smooth.

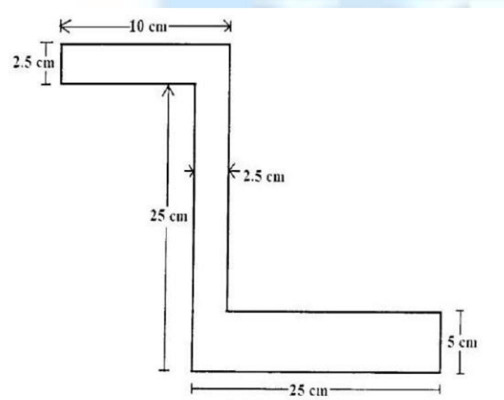


Course outcome identifier	Description of c urse outcome	Learning level assessed	Marks allocated
CO 3	To apply the conditions of equilibrium to various practical problems involving different force system.	Applying – (Sketch the free body diagram that represent equilibrium state of the body)	4
CO 4	To choose appropriate theorems, principles or formulae to solve problems of mechanics.	Applying (Choose the equations and formulae required for calculation)	4
CO 5	To solve problems involving rigid bodies, applying the properties of distributed areas and masses	Applying (Solve the problem based on the descriptions giv n in CO3 and CO4)	6
Total			14

2. A cylindrical disc, 50 cm diameter and cm thickness, is in contact with a horizontal conveyor belts running at uniform speeds of 5   /s. Assuming there is no slip at points of contac determine (i) angular velocity of disc (ii) Angular acceleration of disc if velocity of conveyor changes to 8 m/s. Also compute the moment acting about the axis of the disc in both cases.

Course outcome identifier	Description of course outcome	Learning level assessed	Marks allocated
CO 3	To apply the conditions of equilibrium to various practical problems involving different force system.	Applying – (Sketch the free body diagram that represent state of the body)	4
CO 4	To choose appropriate theorems, principles or formulae to solve problems of mechanics.	Applying (Choose the equations and formulae required for calculation)	4
CO 5	To solve problems involving rigid bodies, applying the properties of distributed areas and masses	Applying (Solve the problem based on the descriptions given in CO3 and CO4)	6
Total			14

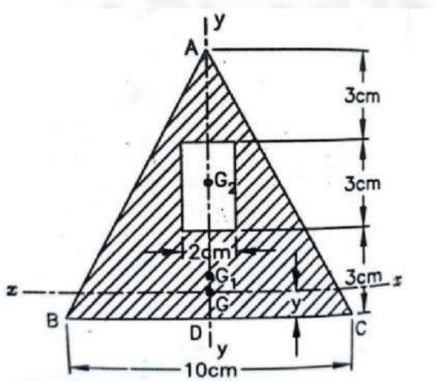
3. Determine the centroid of the given section



Course outcome identifier	Description of course outcome	Learning level assessed	Marks allocated
CO 3	To apply the conditions of equilibrium to various practical problems involving different force system.	Applying – (Illustrate the computation of centroid for the given geometrical shape)	4
CO 4	To choose appropriate theorems, principles or formulae to solve problems of mechanics.	Applying (Choose the equations and formulae required for calculation)	4
CO 5	To solve problems involving rigid bodies, applying the properties of distributed	Applying (Solve the problem based on the descriptions	6

	areas and masses	given in CO3 and CO4)	
Total			14

4. A rectangular hole is made in a triangular section as shown. Find moment of inertia about the section x-x passing through the CG of the section and parallel to BC.



Course outcome identifier	Description of course outcome	Learning level assessed	Marks allocated
CO 3	To apply the conditions of equilibrium to various practical problems involving different force system.	Applying – (Illustrate the computation of moment of inertia for the given geometrical shape)	4
CO 4	To choose appropriate theorems, principles or formulae to solve problems of mechanics.	Applying (Choose the equations and formulae required for calculation)	4
CO 5	To solve problems involving rigid bodies, applying the properties of distributed areas and masses	Applying (Solve the problem based on the descriptions given in CO3 and CO4)	6
Total			14

Model Question Paper

QP CODE:

Reg No.:_______________

Name:__________________________ ____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY FIRST SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: EST 100

ENGINEERING MECHANICS

Max. Marks: 100 Duration: 3 hours

Part A

(Answer all questions; each question carries 3 marks)

1. Explain D'Alembert's principle

2. Distinguish static and dynamic frictioni.

3. State and explain perpendicular axis theorem.

4. A simply supported beam AB of span 5 m is carrying point loads 5 kN, 3 kN and 2 kN at 1m, 3m and 4m respectively from support A. Calculate the support reaction at B.

5. A gymnast holding onto a bar, is suspended motionless in mid-air. The bar is supported by two ropes that attach to the ceiling. Diagram the forces acting on the combination of gymnast and bar

6. While you are riding your bike, you turn a corner following a circular arc. Illustrate the forces that act on your bike to keep you along the circular path ?

7. Compare damped and undamped free vibrations.

8. State the equation of motion of a rotating rigid body, rotating about its fixed axis.

9. Illustrate the significance of instantaneous centre in the analysis of rigid body undergoing rotational motion.

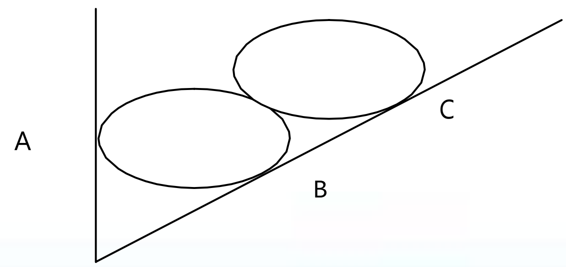
10. Highlight the principles of mechanics applied in the evaluation of elastic collusion of rigid bodies.

PART B

(Answer **one full** question from each module, each question carries **14** marks)

Module -I

11. Two identical rollers each of weight 100 N are supported by an inclined plane, making an angle of 30^{o} with the vertical, and a vertical wall. Find the reaction at the points of contact A, B, C. Assume all the surfaces to be smooth. (14 marks)

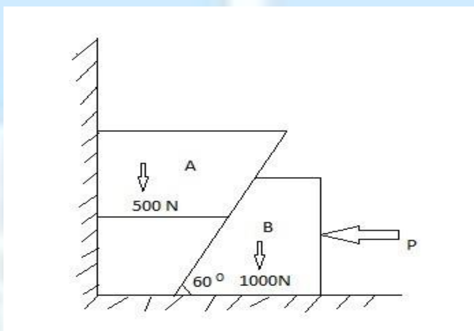


12. A string tied to a wall is made to pass over a pulley placed 2m away from it. A weight P is attached to the string such that the string stretches by 2m from the support on the wall to the location of attachment of weight. Determine the force P required to maintain 200 kg body in position for = 30^o, The diameter of pulley B is negligible. (14 marks)

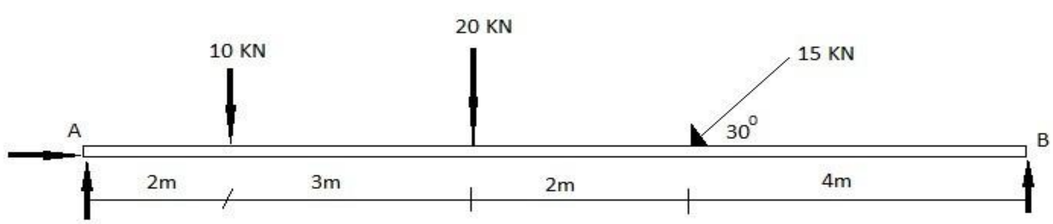
Module – 2

13. Two blocks A & B are resting against a wall and the floor as shown in figure below. Find the value of horizontal force P applied to the lower block that will hold the system in equilibrium. Coefficient of friction are : 0.25 at the floor, 0.3 at the wall and 0.2 between the blocks.

(14 marks)

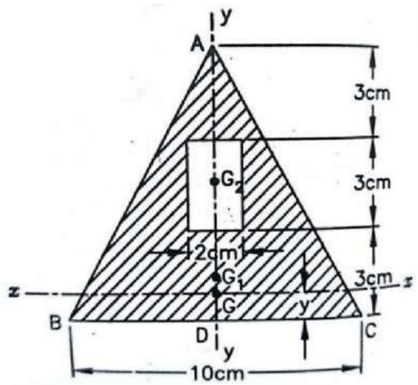


14. A beam is hinged at A and roller supported at B. It is acted upon by loads as shown below. Find the reactions at A & B. (14 marks)

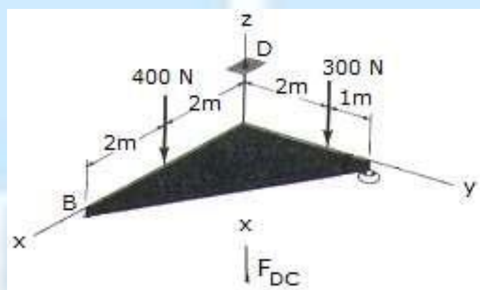


Module – 3

15. A rectangular hole is made in a triangular section as shown. Find moment of inertia about the section x-x passing through the CG of the section and parallel to BC. (14 marks)



16. Support A has ball and socket connection. Roller support at B prevents motion in the —z direction. Corner *C* is tied to *D* by a rope. The triangle is weightless. Determine the unknown force components acting at *A*, *B*, and *C*. (14 marks)



Module - 4

17. A cricket ball is thrown by a fielder from a height of 2m at an angle of 30^0 to the horizontal with an initial velocity of 20 m/s , hits the wickets at a height of 0.5 m from the ground. How far was the fielder from the wicket? (14 marks)

18. An engine of weight 500 kN pull a train weighing 1500 kN up an incline of 1 in 100. The train starts from rest and moves with constant acceleration against a resistance of 5 N/kN. It attains a maximum speed of 36 kmph in 1 km distance. Determine the tension in the coupling between train and engine and the traction force developed by the engine. (14marks)

Module – 5

19. A cylindrical disc, 50 cm diameter and 10 cm thickness having mass of 10 kg, is in contact with a horizontal conveyor belt running at uniform speeds of 5 m/s. Assuming there is no slip at points of contact determine (i) angular velocity of disc (ii) Angular acceleration of disc if velocity of conveyor changes to 8 m/s in 10 seconds. Also compute the moment acting about the axis of the disc in both cases. (14 marks)

20. A wheel rotating about fixed axis at 20 rpm is uniformly accelerated for 70 seconds during which time it makes 50 revolutions. Find the (i) angular velocity at the end of this interval and (ii) time required for the velocity to reach 100 revolutions per minute. (14 marks)

SYLLABUS

Module 1

Introduction to Engineering Mechanics-statics-basic principles of statics-Parallelogram law, equilibrium law, principles of superposition and transmissibility, law of action and reaction(review) free body diagrams.

Concurrent coplanar forces-composition and resolution of forces-resultant and equilibrium equations – methods of projections – methods of moments – Varignon's Theorem of moments.

Module 2

Friction – sliding friction - Coulomb's laws of friction – analysis of single bodies –wedges, ladder-analysis of connected bodies .

Parallel coplanar forces – couple - resultant of parallel forces – centre of parallel forces – equilibrium of parallel forces – Simple beam subject to concentrated vertical loads. General coplanar force system - resultant and equilibrium equations.

Module 3

Centroid of composite areas- – moment of inertia-parallel axis and perpendicular axis theorems. Polar moment of inertia,radius of gyration,mass moment of inertia-ring,cylinder and disc.

Theorem of Pappus Guldinus(demonstration only)

Forces in space - vectorial representation of forces, moments and couples –resultant and equilibrium equations – concurrent forces in space (simple problems only)

Module 4

Dynamics – rectilinear translation - equations of kinematics(review)

kinetics – equation of motion – D'Alembert's principle. – motion on horizontal and inclined surfaces, motion of connected bodies. Impulse momentum equation and work energy equation (concepts only).

Curvilinear translation - equations of kinematics –projectile motion(review), kinetics – equation of motion. Moment of momentum and work energy equation (concepts only).

Module 5

Rotation – kinematics of rotation- equation of motion for a rigid body rotating about a fixed axis – rotation under a constant moment.

Plane motion of rigid body – instantaneous centre of rotation (concept only).

Simple harmonic motion – free vibration –degree of freedom- undamped free vibration of spring mass system-effect of damping(concept only)

Text Books

1. Timoshenko and Young, Engineering Mechanics, McGraw Hill Publishers
2. Shames, I. H., Engineering Mechanics - Statics and Dynamics, Prentice Hall of India.
3. R. C. Hibbeler and Ashok Gupta, Engineering Mechanics, Vol. I statics, Vol II Dynamics, Pearson Education.

References

1. Merriam J. L and Kraige L. G., Engineering Mechanics - Vols. 1 and 2, John Wiley.

2. Tayal A K, Engineering Mechanics – Statics and Dynamics, Umesh Publications

3. Bhavikkatti, S.S., Engineering Mechanics, New Age International Publishers

4. F.P.Beer abd E.R.Johnston (2011), Vector Mechanics for Engineers, Vol.I-Statics, Vol.II-Dynamics, 9th Ed, Tata McGraw Hill

5. Rajasekaran S and Sankarasubramanian G, Engineering Mechanics - Statics and Dynamics, Vikas Publishing House Pvt Ltd.

Course Contents and Lecture Schedule:

Module	Topic	Course outcomes addressed	No. of Hours
1	**Module 1**		**Total: 7**
1.1	Introduction to engineering mechanics – introduction on statics and dynamics - Basic principles of statics – Parellogram law, equilibrium law – Superposition and transmissibility, law of action and reaction (review the topics)	CO1 and CO2	1
1.2	Free body diagrams. Degree of freedom-types of supports and nature of reactions - exercises for free body diagram preparation – composition and resolution of forces, resultant and equilibrium equations (review the topics) - numerical exercises for illustration.	CO1 and CO2	1
1.3	Concurrent coplanar forces - analysis of concurrent forces -methods of projections – illustrative numerical exercise – teacher assisted problem solving.	CO1 and CO2	1
1.4	Analysis of concurrent forces -methods of moment-Varignon's Theorem of Moments - illustrative numerical exercise– teacher assisted problem solving.	CO1 and CO2	1
1.5	Analysis of concurrent force systems – extended problem solving - Session I.	CO3,CO4 and CO5	1
1.6	Analysis of concurrent force systems – extended problem solving - Session II – learning review quiz.	CO3,CO4 and CO5	1
1.7	Analysis of concurrent force systems – extended problem solving - Session III.	CO3,CO4 and CO5	1
2	**Module 2**		**Total: 7**
2.1	Friction – sliding friction - Coulomb's laws of friction – analysis of single bodies –illustrative examples on wedges and ladder-teacher	CO1 and CO2	1

	assisted problem solving tutorials using problems from wedges and ladder.		
2.2	Problems on friction - analysis of connected bodies. illustrative numerical exercise– teacher assisted problem solving.	CO3, CO4 and CO5	1
2.3	Problems on friction-extended problem solving	CO3,C04 and CO5	1
2.4	Parallel coplanar forces – couple - resultant of parallel forces – centre of parallel forces – equilibrium of parallel forces – Simple beam subject to concentrated vertical loads.	CO1 and CO2	1
2.5	General coplanar force system - resultant and equilibrium equations - illustrative examples- teacher assisted problem solving.	CO1 and CO2	1
2.6	General coplanar force system-resultant and equilibrium equations - illustrative examples	CO3, CO4 and CO5	1
2.7	General coplanar force system - Extended problem solving - Quiz to evaluate learning level.	CO3, CO4 and CO5	1
3	**Module 3**		**Total: 7**
3.1	Centroid of simple and regular geometrical shapes – centroid of figures in combination - composite areas- examples for illustration – problems for practice to be done by self.	CO1 and CO2	1
3.2	Moment of inertia- parallel axis theorem –examples for illustration - problems for practice to be done by self.	CO1 and CO2	1
3.3	Moment of inertia - perpendicular axis theorem - example for illustration to be given as hand out and discussion on the solved example.	CO1 and CO2	1
3.4	Solutions to practice problems – problems related to centroid and moment of inertia - problems for practice to be done by self.	CO3, CO4 and CO5	1
3.5	Polar moment of inertia, Radius of gyration. Mass moment of inertia of ring, cylinder and uniform disc. Theorem of Pappus Guldinus - Demonstration	CO1 and CO2	1
3.6	Introduction to forces in space – vectorial representation of forces, moments and couples – simple problems to illustrate vector representations of forces, moments and couples to be done in class.	CO1,and CO2	1
3.7	Solution to practice problems - resultant and equilibrium equations for concurrent forces in space – concurrent forces in space - 2 simple problems to illustrate the application of resultant and equilibrium equations for concurrent forces in space.	CO3,CO4 and CO5	1
4	**Module 4**		**Total: 7**

4.1	Introduction to dynamics – review of rectilinear translation - equations of kinematics – problems to review the concepts – additional problems involving extended application as exercises .	CO1 and CO2	1
4.2	Solutions to exercises with necessary explanation given as hand out – introduction to kinetics – equation of motion – D'Alembert's principle – illustration of the concepts using one numerical exercise from motion on horizontal and inclined surfaces.	CO1 and CO2	1
4.3	Motion of connected bodies - example for illustration to be given as hand out and discussion on the solved example – problems for practice to be done by self.	CO3, CO4 and CO5	1
4.4	Motion of connected bodies-extended problem solving.	CO3, CO4 & CO5	1
4.5	Curvilinear translation - Review of kinematics –projectile motion – simple problems to review the concepts – introduction to kinetics – equation of motion – illustration of the concepts using numerical exercises.	CO3, CO4 & CO5	1
4.6	Extended problem solving – rectilinear and curvilinear translation.	CO3, CO4 & CO5	1
4.7	Concepts on Impulse momentum equation and work energy equation (rectilinear translation – discussions to bring out difference between elastic and inelastic collusions). Concepts on Moment of momentum and work energy equation (curvilinear translation).	CO1 and CO2	1
5	**Module 5**		**Total: 7**
5.1	Rotation – kinematics of rotation- equation of motion for a rigid body rotating about a fixed axis – simple problems for illustration.	CO1 and CO2	1
5.2	Rotation under a constant moment – teacher assisted problem solving.	CO3,CO4 and CO5	1
5.3	Rotation under a constant moment - extended problem solving.	CO3, CO4 and CO5	1
5.4	Plane motion of rigid body- instantaneous centre of rotation (concept only).	CO1 and CO2	1
5.5	Introduction to harmonic oscillation –free vibrations - simple harmonic motion – differential equation and solution. Degree of freedom – examples of single degree of freedom (SDOF) systems – Idealisation of mechanical systems as spring-mass systems (concept only).	CO1 and CO2	1

5.6	SDOF spring mass system –equation of motion – undamped free vibration response - concept of natural frequency. Free vibration response due to initial conditions. Simple problems on determination of natural frequency and free vibration response to test the understanding level.	CO1 and CO2	1
5.7	Free vibration analysis of SDOF spring-mass systems – Problem solving Effect of damping on free vibration response (concept only).	CO1and CO2	1

EST 130	BASICS OF ELECTRICAL AND ELECTRONICS ENGINEERING	CATEGORY	L	T	P	CREDIT	YEAR OF INTRODUCTION
		ESC	4	0	0	4	2019

Preamble:

This course aims to (1) equip the students with an understanding of the fundamental principles of electrical engineering(2) provide an overview of evolution of electronics, and introduce the working principle and examples of fundamental electronic devices and circuits (3) provide an overview of evolution of communication systems, and introduce the basic concepts in radio communication.

Prerequisite: Physics and Mathematics (Pre-university level)

Course Outcomes: After the completion of the course the student will be able to

CO 1	Apply fundamental concepts and circuit laws to solve simple DC electric circuits
CO 2	Develop and solve models of magnetic circuits
CO 3	Apply the fundamental laws of electrical engineering to solve simple ac circuits in steady state
CO 4	Describe working of a voltage amplifier
CO 5	Outline the principle of an electronic instrumentation system
CO 6	Explain the principle of radio and cellular communication

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	1	-	-	-	-	-	-	-	-	-	2
CO 2	3	1	-	-	-	-	-	-	-	-	-	2
CO 3	3	1	-	-	-	-	-	-	-	-	-	2
CO 4	2	-	-	-	-	-	-	-	-	-	-	-
CO 5	2	-	-	-	-	-	-	-	-	-	-	2
CO 6	2	-	-	-	-	-	-	-	-	-	-	2

Assessment Pattern

Bloom's Category	Basic Electrical Engineering			Basic Electronics Engineering		
	Continuous Assessment Tests		End Semester Examination (Marks)	Continuous Assessment Tests		End Semester Examination (Marks)
	Test 1 (Marks)	Test 2 (Marks)		Test 1 (Marks)	Test 2 (Marks)	
Remember	0	0	10	10	10	20
Understand	12.5	12.5	20	15	15	30
Apply	12.5	12.5	20			
Analyse						
Evaluate						
Create						

Mark distribution

Total Marks	CIE marks	ESE marks	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks

Continuous Assessment Test (2 numbers) : 25 marks

Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part I – Basic Electrical Engineering and Part II – Basic Electronics Engineering. Part I and PART II carries 50 marks each. For the end semester examination, part I contain 2 parts - Part A and Part B. Part A contain 5 questions carrying 4 marks each (not exceeding 2 questions from each module). Part B contains 2 questions from each module out of which one to be answered. Each question carries 10 mark and can have maximum 2 sub-divisions. The pattern for end semester examination for part II is same as that of part I. **However, student should answer both part I and part 2 in separate answer booklets.**

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Solve problems based on current division rule.

2. Solve problems with Mesh/node analysis.

3. Solve problems on Wye-Delta Transformation.

Course Outcome 2 (CO2):

1. Problems on series magnetic circuits

2. Problems on parallel magnetic circuits

3. Problems on composite magnetic ciruits

4. Course Outcome 3 (CO3):

1. problems on self inductance, mutual inductance and coefficient of coupling

2. problems on rms and average values of periodic waveforms

3. problems on series ac circuits

4. Compare star and Delta connected 3 phase AC systems.

Course Outcome 4 (CO4): Describe working of a voltage amplifier

1.What is the need of voltage divider biasing in an RC coupled amplifier?

2. Define operating point in the context of a BJT amplifier.

3. Why is it required to have a voltage amplifier in a public address system?

Course Outcome 5 (CO5): Outline the principle of an electronic instrumentation system

1. Draw the block diagram of an electronic instrumentation system.

2. What is a transducer?

3. Explain the working principle of operation of digital multimeter.

Course Outcome 6 (CO6): Explain the principle of radio and cellular communication

1. What is the working principle of an antenna when used in a radio transmitter?

2. What is the need of two separate sections RF section and IF section in a super heterodyne receiver?

3. What is meant by a cell in a cellular communication?

Model Question Paper

QP CODE: Pages: 3

Reg No.:_________________

Name:___________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY FIRST SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: EST 130

Course Name: BASICS OF ELECTRICAL AND ELECTRONICS ENGINEERING

Max. Marks: 100 Duration: 3 hours

Answer both part I and part 2 in separate answer booklets

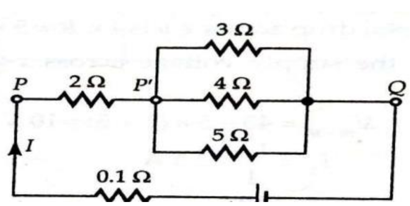
PART I

BASIC ELECTRICAL ENGINEERING

PART A

Answer all questions; each question carries 4 marks.

1. Calculate the current through the 4Ω resistor in the circuit shown, applying current division rule:



2. Calculate the RMS and average values of a purely sinusoidal current having peak value 15A.

3. An alternating voltage of (80+j60)V is applied to an RX circuit and the current flowing through the circuit is (-4+j10)A. Calculate the impedance of the circuit in rectangular and polar forms. Also determine if X is inductive or capacitive.

4. Derive the relation between line and phase values of voltage in a three phase star connected system.

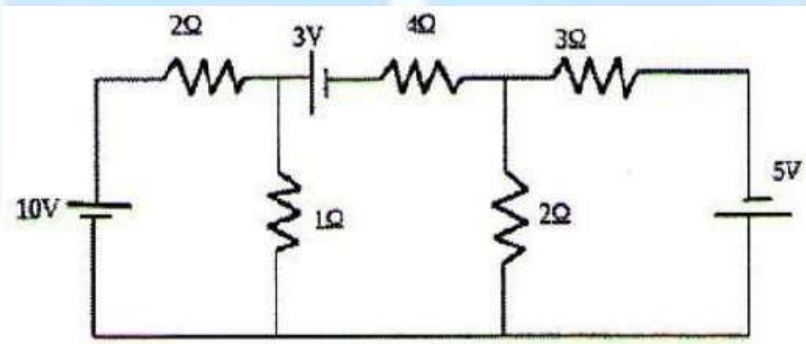
5. Compare electric and magnetic circuits. *(5x4=20)*

PART B

Answer one question from each module; each question carries 10 marks.

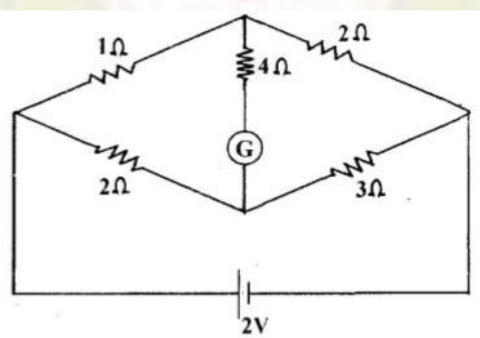
Module 1

6. . Calculate the node voltages in the circuit shown, applying node analysis:



7. (a) State and explain Kirchhoff's laws. (4 marks)

(b) Calculate the current through the galvanometer (G) in the circuit shown:



(6 marks)

Module 2

8. (a) State and explain Faraday's laws of electromagnetic induction with examples. (4 marks)

(b) Differentiate between statically and dynamically induced emf. A conductor of length 0.5m moves in a uniform magnetic field of flux density 1.1T at a velocity of 30m/s. Calculate the emf induced in the conductor if the direction of motion of the conductor is inclined at 60^0 to the direction of field. (6 marks)

9. (a) Derive the amplitude factor and form factor of a purely sinusoidal waveform. (5 marks)

(b) A current wave is made up of two components-a 5A dc component and a 50Hz ac component, which is a sinusoidal wave with a peak value of 5A. Sketch the resultant waveform and determine its RMS and average values. (5 marks)

Module 3

10. Draw the power triangle and define active, reactive and apparent powers in ac circuits. Two coils A and B are connected in series across a 240V, 50Hz supply. The resistance of A is 5 □ and the inductance of B is 0.015H. If the input from the supply is 3kW and 2kVAR, find the inductance of A and the resistance of B. Also calculate the voltage acrosseach coil.

11. A balanced three phase load consists of three coils each having resistance of 4Ω and inductance 0.02H. It is connected to a 415V, 50Hz, 3-phase ac supply. Determine the phase voltage, phase current, power factor and active power when the loads are connected in (i) star (ii) delta.

(3x10=30)

PART II

BASIC ELECTRONICS ENGINEERING

PART A

Answer all questions; each question carries 4 marks.

1. Give the specifications of a resistor. The colour bands marked on a resistor are Blue, Grey, Yellow and Gold. What are the minimum and maximum resistance values expected from that resistance?
2. What is meant by avalanche breakdown?
3. Explain the working of a full-wave bridge rectifier.
4. Discuss the role of coupling and bypass capacitors in a single stage RC coupled amplifier.
5. Differentiate AM and FM communication systems.

(5x4=20)

PART B

Answer one question from each module; each question carries 10 marks.

Module 4

6. a) Explain with diagram the principle of operation of an NPN transistor. (5)
   b) Sketch and explain the typical input-output characteristics of a BJT when connected in common emitter configuration. (5)

OR

7. a) Explain the formation of a potential barrier in a P-N junction diode. (5)
   b) What do you understand by Avalanche breakdown? Draw and explain the V-I characteristics of a P-N junction and Zener diode. (5)

Module 5

8. a) With a neat circuit diagram, explain the working of an RC coupled amplifier. (6)
   b) Draw the frequency response characteristics of an RC coupled amplifier and state the reasons for the reduction of gain at lower and higher frequencies. (4)

OR

9. a) With the help of block diagram, explain how an electronic instrumentation system. (6)
   b) Explain the principle of an antenna. (4)

Module 6

10. a) With the help of a block diagram, explain the working of Super hetrodyne receiver. (6)
    b) Explain the importance of antenna in a communication system. (4)

OR

11. a) With neat sketches explain a cellular communication system. (5)
    b) Explain GSM communication with the help of a block diagram. (5)

(3x10=30)

SYLLABUS

MODULE 1: Elementary Concepts of Electric Circuits

Elementary concepts of DC electric circuits: Basic Terminology including voltage, current, power, resistance, emf; Resistances in series and parallel; Current and Voltage Division Rules; Capacitors & Inductors: V-I relations and energy stored. Ohms Law and Kirchhoff's laws-Problems; Star-delta conversion (resistive networks only-derivation not required)-problems.

Analysis of DC electric circuits: Mesh current method - Matrix representation - Solution of network equations. Node voltage methods-matrix representation-solution of network equations by matrix methods. Numerical problems.

MODULE 2: Elementary Concepts of Magnetic circuits, Electromagnetic Induction and AC fundamentals

Magnetic Circuits: Basic Terminology: MMF, field strength, flux density, reluctance - comparison between electric and magnetic circuits- Series and parallel magnetic circuits with composite materials, numerical problems.

Electromagnetic Induction: Faraday's laws, problems, Lenz's law- statically induced and dynamically induced emfs - Self-inductance and mutual inductance, coefficient of coupling

Alternating Current fundamentals: Generation of alternating voltages-Representation of sinusoidal waveforms: frequency, period, Average, RMS values and form factor of waveforms-Numerical Problems.

MODULE 3: AC Circuits

AC Circuits: Phasor representation of sinusoidal quantities. Trignometric, Rectangular, Polar and complex forms. Analysis of simple AC circuits: Purely resistive, inductive & capacitive circuits; Inductive and capacitive reactance, concept of impedance. Average Power Power factor. Analysis of RL, RC and RLC series circuits-active, reactive and apparent power. Simple numerical problems.

Three phase AC systems: Generation of three phase voltages; advantages of three phase systems, star and delta connections (balanced only), relation between line and phase voltages, line and phase currents- Numerical problems

MODULE 4

Introduction to Semiconductor devices: Evolution of electronics – Vacuum tubes to nano electronics. Resistors, Capacitors and Inductors (constructional features not required): types, specifications. Standard values, color coding. PN Junction diode: Principle of operation, V-I characteristics, principle of avalanche breakdown. Bipolar Junction Transistors: PNP and NPN structures, Principle of operation, relation between current gains in CE, CB and CC, input and output characteristics of common emitter configuration.

MODULE 5

Basic electronic circuits and instrumentation: Rectifiers and power supplies: Block diagram description of a dc power supply, Working of a full wave bridge rectifier, capacitor filter (no analysis), working of simple zener voltage regulator. Amplifiers: Block diagram of Public Address system, Circuit diagram and working of common emitter (RC coupled) amplifier with its frequency response, Concept of voltage divider biasing. Electronic Instrumentation: Block diagram of an electronic instrumentation system.

MODULE 6

Introduction to Communication Systems: Evolution of communication systems – Telegraphy to 5G. Radio communication: principle of AM & FM, frequency bands used for various communication systems, block diagram of super heterodyne receiver, Principle of antenna – radiation from accelerated charge. Mobile communication: basic principles of cellular communications, principle and block diagram of GSM.

Text Books

1. D P Kothari and I J Nagrath, "Basic Electrical Engineering", Tata McGraw Hill, 2010.
2. D C Kulshreshtha, "Basic Electrical Engineering", Tata McGraw Hill, 2010.
3. ChinmoySaha, Arindham Halder and Debarati Ganguly, Basic Electronics - Principles and Applications, Cambridge University Press, 2018.
4. M.S.Sukhija and T.K.Nagsarkar, Basic Electrical and Electronics Engineering, Oxford University Press, 2012.
5. Wayne Tomasi and Neil Storey, A Textbook On Basic Communication and Information Engineering, Pearson, 2010.

Reference Books

1. Del Toro V, "Electrical Engineering Fundamentals", Pearson Education.
2. T. K. Nagsarkar, M. S. Sukhija, "Basic Electrical Engineering", Oxford Higher Education.
3. Hayt W H, Kemmerly J E, and Durbin S M, "Engineering Circuit Analysis", Tata McGraw-Hill
4. Hughes, "Electrical and Electronic Technology", Pearson Education.
5. V. N. Mittle and Arvind Mittal, "Basic Electrical Engineering," Second Edition, McGraw Hill.
6. Parker and Smith, "Problems in Electrical Engineering", CBS Publishers and Distributors.
7. S. B. Lal Seksena and Kaustuv Dasgupta, "Fundamentals of Electrical Engineering", Cambridge University Press.
8. Anant Agarwal, Jeffrey Lang, Foundations of Analog and Digital Electronic Circuits, Morgan Kaufmann Publishers, 2005.
9. Bernard Grob, Ba sic Electronics, McGraw Hill.
10. A. Bruce Carlson, Paul B. Crilly, Communication Systems: An Introduction to Signals and Noise in Electrical Communication, Tata McGraw Hill, 5th Edition.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures
1	***Elementary Concepts of Electric Circuits***	
1.1	**Elementary concepts of DC electric circuits:** Basic Terminology including voltage, current, power, resistance, emf; Resistances in series and parallel; Current and Voltage Division Rules; Capacitors & Inductors: V-I relations and energy stored. Ohms Law and Kirchhoff's laws-Problems; Star-delta conversion (resistive networks only-derivation not required)-problems.	1 2 1
1.2	**Analysis of DC electric circuits:** Mesh current method - Matrix representation - Solution of network equations. Node voltage methods-matrix representation-solution of network equations by matrix methods. Numerical problems.	1 1 2
2	**Elementary Concepts of Magnetic circuits, Electromagnetic Induction and AC fundamentals**	
2.1	**Magnetic Circuits:** Basic Terminology: MMF, field strength, flux density, reluctance - comparison between electric and magnetic circuits- Series and parallel magnetic circuits with composite materials, numerical problems.	1 2
2.2	**Electromagnetic Induction:** Faraday's laws, problems, Lenz's law-statically induced and dynamically induced emfs - Self-inductance and mutual inductance, coefficient of coupling	1 2
2.3	**Alternating Current fundamentals:** Generation of alternating voltages-Representation of sinusoidal waveforms: frequency, period, Average, RMS values and form factor of waveforms-Numerical Problems.	2
3	**AC Circuits**	

3.1	**AC Circuits:** Phasor representation of sinusoidal quantities. Trigonometric, Rectangular, Polar and complex forms. Analysis of simple AC circuits: Purely resistive, inductive & capacitive circuits; Inductive and capacitive reactance, concept of impedance. Average Power, Power factor. Analysis of RL, RC and RLC series circuits-active, reactive and apparent power. Simple numerical problems.	1 2 1 2
3.2	**Three phase AC systems:** Generation of three phase voltages; advantages of three phase systems, star and delta connections (balanced only), relation between line and phase voltages, line and phase currents- Numerical problems.	2
4	**Introduction to Semiconductor devices**	
4.1	Evolution of electronics – Vacuum tubes to nano electronics (In evolutional perspective only)	1
4.2	Resistors, Capacitors and Inductors: types, specifications. Standard values, color coding (No constructional features)	2
4.3	**PN Junction diode**: Principle of operation, V-I characteristics, principle of avalanche breakdown	2
4.4	**Bipolar Junction Transistors:** PNP and NPN structures, Principle of operation, relation between current gains in CE, CB and CC, input and output characteristics of common emitter configuration	3
5	**Basic electronic circuits and instrumentation**	
5.1	**Rectifiers and power supplies:** Block diagram description of a dc power supply, Working of a full wave bridge rectifier, capacitor filter (no analysis), working of simple zener voltage regulator	3
5.2	**Amplifiers:** Block diagram of Public Address system, Circuit diagram and working of common emitter (RC coupled) amplifier with its frequency response, Concept of voltage divider biasing	4
5.3	**Electronic Instrumentation:** Block diagram of an electronic instrumentation system	2
6	**Introduction to Communication Systems**	
6.1	Evolution of communication systems – Telegraphy to 5G	1

6.2	**Radio communication:** principle of AM & FM, frequency bands used for various communication systems, block diagram of super heterodyne receiver, Principle of antenna – radiation from accelerated charge	4
6.3	**Mobile communication:** basic principles of cellular communications, principle and block diagram of GSM.	2

Suggested Simulation Assignments for Basic Electronics Engineering

1. Plot V-I characteristics of Si and Ge diodes on a simulator
2. Plot Input and Output characteristics of BJT on a simulator
3. Implementation of half wave and full wave rectifiers
4. Simulation of RC coupled amplifier with the design supplied
5. Generation of AM signal

Note: The simulations can be done on open tools such as QUCS, KiCad, GNURadio or similar software to augment the understanding.

HUN 101	LIFE SKILLS	CATEGORY	L	T	P	CREDIT	YEAR OF INTRODUCTION
		MNC	2	0	2	---	**2019**

Preamble: Life skills are those competencies that provide the means for an individual to be resourceful and positive while taking on life's vicissitudes. Development of one's personality by being aware of the self, connecting with others, reflecting on the abstract and the concrete, leading and generating change, and staying rooted in time-tested values and principles is being aimed at. This course is designed to enhance the employability and maximize the potential of the students by introducing them to the principles that underly personal and professional success, and help them acquire the skills needed to apply these principles in their lives and careers.

Prerequisite: None

Course Outcomes: After the completion of the course the student will be able to

CO 1	Define and Identify different life skills required in personal and professional life
CO 2	Develop an awareness of the self and apply well-defined techniques to cope with emotions and stress.
CO 3	Explain the basic mechanics of effective communication and demonstrate these through presentations.
CO 4	Take part in group discussions
CO 5	Use appropriate thinking and problem solving techniques to solve new problems
CO 6	Understand the basics of teamwork and leadership

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1						2		1	2	2	1	3
CO 2									3			2
CO 3						1			1	3		
CO 4										3		1
CO 5		3	2	1								
CO 6						1			3			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	50	50	2 hours

Continuous Internal Evaluation
Total Marks: 50

Attendance	: 10 marks
Regular assessment	: 15 marks
Series test (one test only, should include first three modules)	: 25 marks

Regular assessment

- Group Discussion (Marks: 9)

  Create groups of about 6 students each and engage them on a GD on a suitable topic for about 20 minutes. Parameters to be used for evaluation are as follows:

  - Communication Skills : 3 marks
  - Subject Clarity : 2 marks
  - Group Dynamics : 2 marks
  - Behaviours & Mannerisms : 2 marks

- Presentation Skills (Marks: 6)

  Identify a suitable topic and ask the students to prepare a presentation (preferably a power point presentation) for about 10 minutes. Parameters to be used for evaluation are as follows:

  - Communication Skills : 2 marks
  - Platform Skills : 2 marks
  - Subject Clarity/Knowledge : 2 marks

End Semester Examination
Total Marks: 50 **Time: 2 hrs.**

Part A: Short answer question (25 marks)
There will be one question from each MODULE (five questions in total, five marks each). Each question should be written in about maximum of 400 words. Parameters to be used for evaluation are as follows:
(i) Content Clarity/Subject Knowledge
(ii) Presentation style
(iii) Organization of content

Part B: Case Study (25 marks)
The students will be given a case study with questions at the end. The students have to analyze the case and answer the question at the end. Parameters to be used for evaluation are as follows:
(i) Analyze the case situation
(ii) Key players/characters of the case
(iii) Identification of the problem (both major & minor if exists)
(iv) Bring out alternatives
(v) Analyze each alternative against the problem
(vi) Choose the best alternative
(vii) Implement as solution
(viii) Conclusion

(ix) Answer the question at the end of the case

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. List 'life skills' as identified by WHO
2. What do you mean by effective communication?
3. What are the essential life skills required by a professional?

Course Outcome 2 (CO2)

1. Identify an effective means to deal with workplace stress.
2. How can a student apply journaling to stress management?
3. What is the PATH method? Describe a situation where this method can be used effectively.

Course Outcome 3(CO3):

1. Identify the communication network structure that can be observed in the given situations. Describe them.

   (a) A group discussion on development.

   (b) An address from the Principal regarding punctuality.

   (c) A reporter interviewing a movie star.

   (d) Discussing the answers of a test with a group of friends.

2. Elucidate the importance of non-verbal communication in making a presentation
3. Differentiate between kinesics, proxemics, and chronemics with examples.

Course Outcome 4 (CO4):

1. How can a participant conclude a group discussion effectively?
2. 'Listening skills are essential for effectively participating in a group discussion.' Do you agree? Substantiate your answer.

Course Outcome 5 (CO5):

1. Illustrate the creative thinking process with the help of a suitable example
2. Translate the following problem from verbal to graphic form and find the solution : *In a quiz, Ananth has 50 points more than Bimal, Chinmay has 60 points less than Ananth, and Dharini is 20 points ahead of Chinmay. What is the difference in points between Bimal and Dharini?*

3. List at least five ways in which the problem "How to increase profit?" can be redefined

Course Outcome 6 (CO6):

1. A group of engineers decided to brainstorm a design issue on a new product. Since no one wanted to disagree with the senior members, new ideas were not flowing freely. What group dynamics technique would you suggest to avoid this 'groupthink'? Explain the procedure.

2. “A group focuses on individual contribution, while a team must focus on synergy.” Explain.

3. Identify the type of group formed / constituted in each of the given situations

   a) A Police Inspector with subordinates reporting to him

   b) An enquiry committee constituted to investigate a specific incident

   c) The Accounts Department of a company

   d) A group of book lovers who meet to talk about reading

Syllabus

Module 1

Overview of Life Skills: Meaning and significance of life skills, Life skills identified by WHO: Self-awareness, Empathy, Critical thinking, Creative thinking, Decision making, problem solving, Effective communication, interpersonal relationship, coping with stress, coping with emotion.

Life skills for professionals: positive thinking, right attitude, attention to detail, having the big picture, learning skills, research skills, perseverance, setting goals and achieving them, helping others, leadership, motivation, self-motivation, and motivating others, personality development, IQ, EQ, and SQ

Module 2

Self-awareness: definition, need for self-awareness; Coping With Stress and Emotions, Human Values, tools and techniques of SA: questionnaires, journaling, reflective questions, meditation, mindfulness, psychometric tests, feedback.

Stress Management: Stress, reasons and effects, identifying stress, stress diaries, the four A's of stress management, techniques, Approaches: action-oriented, emotion-oriented, acceptance-oriented, resilience, Gratitude Training,

Coping with emotions: Identifying and managing emotions, harmful ways of dealing with emotions, PATH method and relaxation techniques.

Morals, Values and Ethics: Integrity, Civic Virtue, Respect for Others, Living Peacefully. Caring, Sharing, Honesty, Courage, Valuing Time, Time management, Co operation, Commitment, Empathy, Self-Confidence, Character, Spirituality, Avoiding Procrastination, Sense of Engineering Ethics.

Module 3

21st century skills: Creativity, Critical Thinking, Collaboration, Problem Solving, Decision Making, Need for Creativity in the 21st century, Imagination, Intuition, Experience, Sources of Creativity, Lateral Thinking, Myths of creativity, Critical thinking Vs Creative thinking, Functions of Left Brain & Right brain, Convergent & Divergent Thinking, Critical reading & Multiple Intelligence.

Steps in problem solving: Problem Solving Techniques, Six Thinking Hats, Mind Mapping, Forced Connections. Analytical Thinking, Numeric, symbolic, and graphic reasoning. Scientific temperament and Logical thinking.

Module 4

Group and Team Dynamics: Introduction to Groups: Composition, formation, Cycle, thinking, Clarifying expectations, Problem Solving, Consensus, Dynamics techniques, Group vs Team, Team Dynamics, Virtual Teams. Managing team performance and managing conflicts, Intrapreneurship.

Module 5

Leadership: Leadership framework, entrepreneurial and moral leadership, vision, cultural dimensions. Growing as a leader, turnaround leadership, managing diverse stakeholders, crisis management. Types of Leadership, Traits, Styles, VUCA Leadership, Levels of Leadership, Transactional vs Transformational Leaders, Leadership Grid, Effective Leaders.

Lab Activities

Verbal

Effective communication and Presentation skills.
Different kinds of communication; Flow of communication; Communication networks, Types of barriers; Miscommunication
Introduction to presentations and group discussions.
Learning styles: visual, aural, verbal, kinaesthetic, logical, social, solitary; Previewing, KWL table, active listening, REAP method
Note-taking skills: outlining, non-linear note-taking methods, Cornell notes, three column note taking.
Memory techniques: mnemonics, association, flashcards, keywords, outlines, spider diagrams and mind maps, spaced repetition.
Time management: auditing, identifying time wasters, managing distractions, calendars and checklists; Prioritizing - Goal setting, SMART goals; Productivity tools and apps, Pomodoro technique.

Non Verbal:
Non-verbal Communication and Body Language: Forms of non-verbal communication; Interpreting body-language cues; Kinesics; Proxemics; Chronemics; Effective use of body language, Communication in a multi cultural environment.

Reference Books

1. Shiv Khera, You Can Win, Macmillan Books, New York, 2003.
2. Barun K. Mitra, “Personality Development & Soft Skills”, Oxford Publishers, Third impression, 2017.
3. ICT Academy of Kerala, "Life Skills for Engineers", McGraw Hill Education (India) Private Ltd., 2016.
4. Caruso, D. R. and Salovey P, “The Emotionally Intelligent Manager: How to Develop and Use the Four Key Emotional Skills of Leadership”, John Wiley & Sons, 2004.
5. Kalyana, “Soft Skill for Managers”; First Edition; Wiley Publishing Ltd, 2015.
6. Larry James, “The First Book of Life Skills”; First Edition, Embassy Books, 2016.
7. Shalini Verma, “Development of Life Skills and Professional Practice”; First Edition; Sultan Chand (G/L) & Company, 2014.
8. Daniel Goleman, "Emotional Intelligence"; Bantam, 2006.
9. Remesh S., Vishnu R.G., "Life Skills for Engineers", Ridhima Publications, First Edition, 2016.
10. Butterfield Jeff, “Soft Skills for Everyone”, Cengage Learning India Pvt Ltd; 1 edition, 2011.
11. Training in Interpersonal Skills: Tips for Managing People at Work, Pearson Education, India; 6 edition, 2015.
12. The Ace of Soft Skills: Attitude, Communication and Etiquette for Success, Pearson Education; 1 edition, 2013.

PHL 120	ENGINEERING PHYSICS LAB	CATEGORY	L	T	P	CREDIT	YEAR OF INTRODUCTION
		BSC	0	0	2	1	2019

Preamble: The aim of this course is to make the students gain practical knowledge to co-relate with the theoretical studies and to develop practical applications of engineering materials and use the principle in the right way to implement the modern technology.

Prerequisite: Higher secondary level Physics

Course Outcomes: After the completion of the course the student will be able to

CO 1	Develop analytical/experimental skills and impart prerequisite hands on experience for engineering laboratories
CO 2	Understand the need for precise measurement practices for data recording
CO 3	Understand the principle, concept, working and applications of relevant technologies and comparison of results with theoretical calculations
CO 4	Analyze the techniques and skills associated with modern scientific tools such as lasers and fiber optics
CO 5	Develop basic communication skills through working in groups in performing the laboratory experiments and by interpreting the results

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3				3			1	2			1
CO 2	3				3			1	2			1
CO 3	3				3			1	2			1
CO 4	3				3			1	2			1
CO 5	3				3			1	2			1

Mark distribution

Total Marks	CIE Marks	ESE Marks	ESE Duration(Internal)
100	100	-	1 hour

Continuous Internal Evaluation Pattern:

Attendance : 20 marks
Class work/ Assessment /Viva-voce : 50 marks
End semester examination (Internally by college) : 30 marks

End Semester Examination Pattern: Written Objective Examination of one hour

SYLLABUS

LIST OF EXPERIMENTS

(Minimum 8 experiments should be completed)

1. CRO-Measurement of frequency and amplitude of wave forms
2. Measurement of strain using strain gauge and wheatstone bridge
3. LCR Circuit – Forced and damped harmonic oscillations
4. Melde's string apparatus- Measurement of frequency in the transverse and longitudinal mode
5. Wave length measurement of a monochromatic source of light using Newton's Rings method.
6. Determination of diameter of a thin wire or thickness of a thin strip of paper using air wedge method.
7. To measure the wavelength using a millimeter scale as a grating.
8. Measurement of wavelength of a source of light using grating.
9. Determination of dispersive power and resolving power of a plane transmission grating
10. Determination of the particle size of lycopodium powder
11. Determination of the wavelength of He-Ne laser or any standard laser using diffraction grating
12. Calculate the numerical aperture and study the losses that occur in optical fiber cable.
13. I-V characteristics of solar cell.
14. LED Characteristics.
15. Ultrasonic Diffractometer- Wavelength and velocity measurement of ultrasonic waves in a liquid
16. Deflection magnetometer-Moment of a magnet- Tan A position.

Reference books

1. S.L.Gupta and Dr.V.Kumar, "Practical physics with viva voice", Pragati PrakashanPublishers, Revised Edition, 2009
2. M.N.Avadhanulu, A.A.Dani and Pokely P.M, "Experiments in Engineering Physics", S.Chand&Co,2008
3. S. K. Gupta, "Engineering physics practicals", Krishna Prakashan Pvt. Ltd., 2014
4. P. R. Sasikumar "Practical Physics", PHI Ltd., 2011.

ESL 130	ELECTRICAL & ELECTRONICS WORKSHOP	CATEGORY	L	T	P	CREDIT	YEAR OF INTRODUCTION
		ESC	0	0	2	1	2019

Preamble: Electrical Workshop is intended to impart skills to plan and carry out simple electrical wiring. It is essential for the practicing engineers to identify the basic practices and safety measures in electrical wiring.

Prerequisite: NIL

Course Outcomes: After the completion of the course the student will be able to

CO 1	Demonstrate safety measures against electric shocks.
CO 2	Identify the tools used for electrical wiring, electrical accessories, wires, cables, batteries and standard symbols
CO 3	Develop the connection diagram, identify the suitable accessories and materials necessary for wiring simple lighting circuits for domestic buildings
CO 4	Identify and test various electronic components
CO 5	Draw circuit schematics with EDA tools
CO 6	Assemble and test electronic circuits on boards
CO 7	Work in a team with good interpersonal skills

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	-	-	-	-	-	3	-	-	-	-	-	1
CO 2	2	-	-	-	-	-	-	-	-	1	-	-
CO 3	2	-	-	1	-	1	-	1	2	2	-	2
CO 4	3	-	-	-	-	-	-	-	-	-	-	2
CO 5	3	-	-	-	2	-	-	-	-	-	-	2
CO 6	3	-	-	-	2	-	-	-	-	-	-	1
CO 7	-	-	-	-	-	-	-	-	3	2	-	2

Mark distribution

Total Marks	CIE	ESE	ESE Duration(Internal)
100	100	-	1 hour

Continuous Internal Evaluation Pattern:

Attendance	: 20 marks
Class work/ Assessment /Viva-voce	: 50 marks
End semester examination (Internally by college)	: 30 marks

End Semester Examination Pattern: Written Objective Examination of one hour

Syllabus

PART 1

ELECTRICAL

List of Exercises / Experiments

1. a) Demonstrate the precautionary steps adopted in case of Electrical shocks.

   b)Identify different types of cables, wires, switches, fuses, fuse carriers, MCB, ELCB and MCCB with ratings.
2. Wiring of simple light circuit for controlling light/ fan point (PVC conduit wiring)
3. Wiring of light/fan circuit using Two way switches . (Staircase wiring)
4. Wiring of Fluorescent lamps and light sockets (6A) with a power circuit for controlling power device. (16A socket)
5. Wiring of power distribution arrangement using single phase MCB distribution board with ELCB, main switch and Energy meter.
6. a)Identify different types of batteries with their specifications.

   b)Demonstrate the Pipe and Plate Earthing Schemes using Charts/Site Visit.

PART II

ELECTRONICS

List of Exercises / Experiments (Minimum of 7 mandatory)

1. Familiarization/Identification of electronic components with specification (Functionality, type, size, colour coding, package, symbol, cost etc. [Active, Passive, Electrical, Electronic, Electro-mechanical, Wires, Cables, Connectors, Fuses, Switches, Relays, Crystals, Displays, Fasteners, Heat sink etc.)

2. Drawing of electronic circuit diagrams using BIS/IEEE symbols and introduction to EDA tools (such as Dia or XCircuit), Interpret data sheets of discrete components and IC's, Estimation and costing.

3. Familiarization/Application of testing instruments and commonly used tools. [Multimeter, Function generator, Power supply, DSO etc.] [Soldering iron, De-soldering pump, Pliers, Cutters, Wire strippers, Screw drivers, Tweezers, Crimping tool, Hot air soldering and de- soldering station etc.]

4. Testing of electronic components [Resistor, Capacitor, Diode, Transistor and JFET using multimeter.]

5. Inter-connection methods and soldering practice. [Bread board, Wrapping, Crimping, Soldering - types - selection of materials and safety precautions, soldering practice in connectors and general purpose PCB, Crimping.]

6. Printed circuit boards (PCB) [Types, Single sided, Double sided, PTH, Processing methods, Design and fabrication of a single sided PCB for a simple circuit with manual etching (Ferric chloride) and drilling.]
7. Assembling of electronic circuits using SMT (Surface Mount Technology) stations.
8. Assembling of electronic circuit/system on general purpose PCB, test and show the functioning (**Any Two circuits).**

    1. Fixed voltage power supply with transformer, rectifier diode, capacitor filter, zener/IC regulator.
    2. Square wave generation using IC 555 timer in IC base.
    3. Sine wave generation using IC 741 OP-AMP in IC base.
    4. RC coupled amplifier with transistor BC107.

MAT 102	VECTOR CALCULUS, DIFFERENTIAL EQUATIONS AND TRANSFORMS	CATEGORY	L	T	P	CREDIT	Year of Introduction
		BSC	3	1	0	4	2019

Preamble: This course introduces the concepts and applications of differentiation and integration of vector valued functions, differential equations, Laplace and Fourier Transforms. The objective of this course is to familiarize the prospective engineers with some advanced concepts and methods in Mathematics which include the Calculus of vector valued functions, ordinary differential equations and basic transforms such as Laplace and Fourier Transforms which are invaluable for any engineer's mathematical tool box. The topics treated in this course have applications in all branches of engineering.

Prerequisite: Calculus of single and multi variable functions.

Course Outcomes: After the completion of the course the student will be able to

CO 1	Compute the derivatives and line integrals of vector functions and learn their applications
CO 2	Evaluate surface and volume integrals and learn their inter-relations and applications.
CO 3	Solve homogeneous and non-homogeneous linear differential equation with constant coefficients
CO 4	Compute Laplace transform and apply them to solve ODEs arising in engineering
CO 5	Determine the Fourier transforms of functions and apply them to solve problems arising in engineering

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3	3	3	2	1			1	2		2
CO 2	3	3	3	3	2	1			1	2		2
CO 3	3	3	3	3	2	1			1	2		2
CO 4	3	3	3	3	2	1			1	2		2
CO 5	3	3	3	3	2	1			1	2		2

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination (Marks)
	Test 1 (Marks	Test 2 (Marks)	
Remember	10	10	20
Understand	20	20	40
Apply	20	20	40
Analyse			
Evaluate			

Create			

Mark distribution

Total Marks	CIE (Marks)	ESE (Marks)	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

Assignments: Assignment should include specific problems highlighting the applications of the methods introduced in this course in science and engineering.

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1): Compute the derivatives and line integrals of vector functions and learn their applications

1. How would you calculate the speed, velocity and acceleration at any instant of a particle moving in space whose position vector at time $t$is $\boldsymbol{r}(t)$?
2. Find the work done by the force field $F = (e^x - y^3)\boldsymbol{i} + (\cos y + x^3)$on a particle that travelsonce around the unit circle centred at origin having radius 1.
3. When do you say that a vector field is conservative? What are the implications if a vector field is conservative?

Course Outcome 2 (CO2): Evaluate surface and volume integrals and learn their inter-relations and applications

1. Write any one application each of line integral, double integral and surface integral.
2. Use the divergence theorem to find the outward flux of the vector field $F(x, y, z) = z\boldsymbol{k}$across the

$$x^2 + y^2 + z^2 = a^2$$

3. State Greens theorem. Use Green's theorem to express the area of a plane region bounded by a curve as a line integral.

Course Outcome 3 (CO3): Solve homogeneous and non-homogeneous linear differential equation with constant coefficients

1. If $y_1(x)$ and $y_2(x)$ are solutions of $y'' + py' + qy = 0$, where p, q are constants, show that

   $y_1(x) + y_2(x)$ is also a solution.

2. Solve the differential equation $y'' + y = 0.001x^2$ using method of undetermined coefficient.

3. Solve the differential equation of $y''' - 3y'' + 3y' - y = e^x - x - 1$.

Course Outcome 4 (CO4): Compute Laplace transform and apply them to solve ODEs arising in engineering

1. What is the inverse Laplace Transformof $(s) = \frac{3s-137}{s^2+2s+4}$?

2. Find Laplace Transform of Unit step function.

3. Solve the differential equation of $y'' + 9y = \delta\left(t - \frac{\pi}{2}\right)$? Given $y(0) = 2,\ y'(0) = 0$

Course Outcome 5(CO5): Determine the Fourier transforms of functions and apply them to solve problems arising in engineering

1. Find the Fourier integral representation of function defined by $f(x) = e^{-x}$ for $x > 0$ and $f(x) = 0$ for $x < 0$.

2. What are the conditions for the existence of Fourier Transform of a function $f(x)$?

3. Find the Fourier transform of $f(x) = 1$ for $|x| < 1$ and $f(x) = 0$ otherwise.

Model Question paper

QP CODE: PAGES:3

Reg No:________________

Name :________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY FIRST SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: MAT 102

Max. Marks: 100 **Duration: 3 Hours**

VECTOR CALCULUS, DIFFERENTIAL EQUATIONS AND TRANSFORMS

(2019-Scheme)

(Common to all branches)

PART A

(Answer all questions. Each question carries 3 marks)

1. Is the vector $\boldsymbol{r}$ **where** $\boldsymbol{r} = x\boldsymbol{i} + y\boldsymbol{j} + z\boldsymbol{k}$ conservative. Justify your answer.
2. State Greens theorem including all the required hypotheses
3. What is the outward flux of $\boldsymbol{F}(\boldsymbol{x}, \boldsymbol{y}, \boldsymbol{z}) = x\boldsymbol{i} + y\boldsymbol{j} + z\boldsymbol{k}$ across any unit cube**.**
4. What is the relationship between Green's theorem and Stokes theorem?
5. Solve $y'' + 4y' + 2.5y = 0$
6. Does the function $y = C_1 \cos x + C_2\, sinx$form a solution of$y'' + y = 0$?. Is it the general solution? Justify your answer.
7. Find the Laplace transform of $e^{-t} \sinh 4t$
8. Find the Laplace inverse transform of $\frac{1}{s(s^2+\omega^2)}$.
9. Given the Fourier transform $\frac{1}{\sqrt{2}} e^{-\frac{\omega^2}{4}}$ of $f(x) = e^{-x^2}$, find the Fourier transform of xe^{-x^2}
10. State the convolution theorem for Fourier transform

PART B

(Answer one full question from each module. Each full question carries 14 marks)

MODULE 1

11a) Prove that the force field $\boldsymbol{F} = e^y\boldsymbol{i} + xe^y\boldsymbol{j}$is conservative in the entire xy-plane

b**)** Use Greens theorem to find the area enclosed by the ellipse$\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$

12 a) Find the divergence of the vector field$\boldsymbol{F} = \frac{c}{(x^2+y^2+z^2)^{3/2}}(x\boldsymbol{i} + y\boldsymbol{j} + z\boldsymbol{k})$

b) Find the work done by the force field$\boldsymbol{F}(x, y, z) = xy\boldsymbol{i} + yz\boldsymbol{j} + xz\boldsymbol{k}$along C where

C is the curve$\boldsymbol{r}(t) = t\boldsymbol{i} + t^2\boldsymbol{j} + t^3\boldsymbol{k}$

MODULE II

13 a) Use divergence theorem to find the outward flux of the vector field

$\boldsymbol{F} = 2x\boldsymbol{i} + 3y\boldsymbol{j} + z^3\boldsymbol{k}$acrossthe unit cube bounded by or $x = 0$, $y = 0$,$z = 0$, $x = 1$,$y = 1$,$z = 1$

b) Find the circulation of $\boldsymbol{F} = (x - z)\boldsymbol{i} + (y - x)\boldsymbol{j} + (\boldsymbol{z} - \boldsymbol{xy})\boldsymbol{k}$ using Stokes theorem around the triangle with vertices $A(1,0,0)$, $B(0,2,0)$and $C(0,0,1)$

14 a**)** Use divergence theorem to find the volume of the cylindrical solid bounded by $x^2 + 4x + y^2 = 7$, $z = -1$, $z = 4$, given the vector field $\boldsymbol{F} = \boldsymbol{x}i + \boldsymbol{y}j + \boldsymbol{z}k$ across surfaceof the cylinder

b) Use Stokes theorem to evaluate$\int_C \boldsymbol{F}.\boldsymbol{dr}$where$\boldsymbol{F} = x^2\boldsymbol{i} + 3x\boldsymbol{j} - y^3\boldsymbol{k}$where Cis the circle $x^2 + y^2 = 1$ in the xy- plane with counterclockwise orientation looking down the positive z-axis

MODULE III

15 a) Solve $y'' + 4y' + 4y = x^2 + e^{-x} \cos x$

b) Solve $y''' - 3y'' + 3y' - y = e^x - x - 1$

16 a) Solve $\boldsymbol{y}''' + \boldsymbol{3}y'' + 3y' + y = 30e^{-x}$ given $y(0) = 3, y'(0) = -3\,,\ \ y''(0) = -47$

b) Using method of variation of parameters, solve $y'' + y = sec\ x$

MODULE IV

17 a) Find the inverse Laplace transform of $F(s) = \frac{2(e^{-s} - e^{-3s})\ s^2 -}{4}$

b) Solve the differential equation $y'' + 16y = 4\delta(t - 3\pi);\ y(0) = 2, y'(0) = 0$ using Laplace transform

18 a) Solve $y'' + 3y' + 2y = f(t)$ where $f(t) = 1$ for $0 < t < 1$ and $f(t) = 1$ for $t > 1$ using Laplace transform

b) Apply convolution theorem to find the Laplace inverse transform of $\frac{1}{s^2(s^2+\omega^2)}$

MODULE V

19 a) Find the Fourier cosine integral representation for $f(x) = e^{-kx}$ for $x > 0$ and $k > 0$ and hence evaluate $\int_0^\infty \frac{\cos wx}{k^2+w^2}$ the function

b) Does the Fourier sine transform $f(x) = x^{-1} \sin x$ for $0 < x < \infty$ exist? Justify your answer

20 a) Find the Fourier transform of $f(x) = |x|$ for $|x| < 1$ and $f(x) = 0$ otherwise

b) Find the Fourier cosine transform of $f(x) = e^{-ax}$ for a > 0

Syllabus

Module 1 (Calculus of vector functions)

(Text 1: Relevant topics from sections 12.1, 12.2, 12.6, 13.6, 15.1, 15.2, 15.3)

Vector valued function of single variable, derivative of vector function and geometrical interpretation, motion along a curve-velocity, speed and acceleration. Concept of scalar and vector fields , Gradient and its properties, directional derivative , divergence and curl, Line integrals of vector fields, work as line integral, Conservative vector fields , independence of path and potential function(results without proof).

Module 2 (Vector integral theorems)

(Text 1: Relevant topics from sections 15.4, 15.5, 15.6, 15.7, 15.8)

Green's theorem (for simply connected domains, without proof) and applications to evaluating line integrals and finding areas. Surface integrals over surfaces of the form z = g(x, y), y = g(x, z) or x = g(y, z) , Flux integrals over surfaces of the form z = g(x, y), y = g(x, z) or x = g(y, z), divergence theorem (without proof) and its applications to finding flux integrals, Stokes' theorem (without proof) and its applications to finding line integrals of vector fields and work done.

Module- 3 (Ordinary differential equations)

(Text 2: Relevant topics from sections 2.1, 2.2, 2.5, 2.6, 2.7, 2.10, 3.1, 3.2, 3.3)

Homogenous linear differential equation of second order, superposition principle,general solution, homogenous linear ODEs with constant coefficients-general solution. Solution of Euler-Cauchy equations (second order only).Existence and uniqueness (without proof). Non homogenous linear ODEs-general solution, solution by the method of undetermined coefficients (for the right hand side of the form x^n,e^{kx},$sinax$,$cosax$,$e^{kx}sinax e^{kx}cosax$and their linear combinations), methods of variation of parameters. Solution of higher order equations-homogeneous and non-homogeneous with constant coefficient using method of undetermined coefficient.

Module- 4 (Laplace transforms)

(Text 2: Relevant topics from sections 6.1,6.2,6.3,6.4,6.5)

Laplace Transform and its inverse ,Existence theorem (without proof) , linearity,Laplace transform of basic functions, first shifting theorem, Laplace transform of derivatives and integrals, solution of differential equations using Laplace transform, Unit step function, Second shifting theorems. Dirac delta function and its Laplace transform, Solution of ordinary differential equation involving unit step function and Dirac delta functions. Convolution theorem(without proof)and its application to finding inverse Laplace transform of products of functions.

Module-5 (Fourier Tranforms)

(Text 2: Relevant topics from sections 11.7,11.8, 11.9)

Fourier integral representation, Fourier sine and cosine integrals. Fourier sine and cosine transforms, inverse sine and cosine transform. Fourier transform and inverse Fourier transform, basic properties. The Fourier transform of derivatives. Convolution theorem (without proof)

Text Books

1. H. Anton, I. Biven S.Davis, "Calculus", Wiley, 10th edition, 2015.
2. Erwin Kreyszig, "Advanced Engineering Mathematics", Wiley, 10th edition, 2015.

Reference Books

1. J. Stewart, Essential Calculus, Cengage, 2nd edition, 2017
2. G.B. Thomas and R.L. Finney, Calculus and Analytic geometry, 9 th Edition, Pearson,Reprint, 2002.
3. Peter O Neil, Advanced Engineering Mathematics, 7th Edition, Thomson, 2007.
4. Louis C Barret, C Ray Wylie, "Advanced Engineering Mathematics", Tata McGraw Hill, 6th edition, 2003.
5. VeerarajanT."Engineering Mathematics for first year", Tata McGraw - Hill, 2008.
6. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 36th edition , 2010.
7. Srimanta Pal, Subodh C. Bhunia, "Engineering Mathematics", Oxford University Press, 2015.
8. Ronald N. Bracewell, "The Fourier Transform and its Applications", McGraw – Hill International Editions, 2000.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Calculus of vector functions (9 hours)**	
1.1	Vector valued function of a scalar variable - derivative of vector valued function of scalar variable t-geometrical meaning	2
1.2	Motion along a curve-speed , velocity, acceleration	1
1.3	Gradient and its properties, directional derivative , divergent and curl	3
1.4	Line integrals with respect to arc length, line integrals of vector fields. Work done as line integral	2
1.5	Conservative vector field, independence of path, potential function	1

2	**Vector integral theorems(9 hours)**	
2.1	Green's theorem and it's applications	2
2.2	Surface integrals , flux integral and their evaluation	3
2.3	Divergence theorem and applications	2
2.4	Stokes theorem and applications	2
3	**Ordinary Differential Equations (9 hours)**	
3.1	Homogenous linear equation of second order, Superposition principle, general solution	1
3.2	Homogenous linear ODEs of second order with constant coefficients	2
3.3	Second order Euler-Cauchy equation	1
3.4	Non homogenous linear differential equations of second order with constant coefficient-solution by undetermined coefficients, variation of parameters.	3
3.5	Higher order equations with constant coefficients	2
4	**Laplace Transform (10 hours)**	
4.1	Laplace Transform , inverse Transform, Linearity, First shifting theorem, transform of basic functions	2
4.2	Transform of derivatives and integrals	1
4.3	Solution of Differential equations, Initial value problems by Laplace transform method.	2
4.4	Unit step function --- Second shifting theorem	2
4.5	Dirac Delta function and solution of ODE involving Dirac delta function	2
4.6	Convolution and related problems.	1
5	**Fourier Transform (8 hours)**	
5.1	Fourier integral representation	1
5.2	Fourier Cosine and Sine integrals and transforms	2
5.3	Complex Fourier integral representation, Fourier transform and its inverse transforms, basic properties	3
5.4	Fourier transform of derivatives, Convolution theorem	2

CYT 100	ENGINEERING CHEMISTRY	CATEGORY	L	T	P	CREDIT	YEAR OF INTRODUCTION
		BSC	3	1	0	4	2019

Preamble: To enable the students to acquire knowledge in the concepts of chemistry for engineering applications and to familiarize the students with different application oriented topics like spectroscopy, electrochemistry, instrumental methods etc. Also familiarize the students with topics like mechanism of corrosion, corrosion prevention methods, SEM, stereochemistry, polymers, desalination etc., which enable them to develop abilities and skills that are relevant to the study and practice of chemistry.

Prerequisite: Concepts of chemistry introduced at the plus two levels in schools

Course outcomes: After the completion of the course the students will be able to

CO 1	Apply the basic concepts of electrochemistry and corrosion to explore its possible applications in various engineering fields.
CO 2	Understand various spectroscopic techniques like UV-Visible, IR, NMR and its applications.
CO 3	Apply the knowledge of analytical method for characterizing a chemical mixture or a compound. Understand the basic concept of SEM for surface characterisation of nanomaterials.
CO 4	Learn about the basics of stereochemistry and its application. Apply the knowledge of conducting polymers and advanced polymers in engineering.
CO 5	Study various types of water treatment methods to develop skills for treating wastewater.

Mapping of course outcomes with program outcomes

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**
CO 1	1	2	1									
CO 2	1	1		1	2							
CO 3	1	1		1	2							
CO 4	2	1										
CO 5	1			1			3					

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	15	15	30
Understand	25	25	50
Apply	10	10	20
Analyse			
Evaluate			
Create			

End Semester Examination Pattern: There will be two parts- **Part A** and **Part B. Part A** contains **10** questions (**2** questions from each module), having **3** marks for each question. Students should answer **all** questions. **Part B** contains **2** questions from each module, of which student should answer any one. Each question can have maximum **2** subdivisions and carries **14** marks.

Course Level Assessment Questions

Course Outcome 1 (CO 1):

1. What is calomel electrode? Give the reduction reaction (3 Marks)

2. List three important advantages of potentiometric titration (3 Marks)

3. (a) Explain how electroless plating copper and nickel are carried out (10 Marks)

(b) Calculate the emf of the following cell at 30^{o}C, Z n / Zn $^{2+}$ (0.1M) // Ag^{+} (0.01M) // Ag.

Given E^0 Zn^{2+}/Zn = -0.76 V, E^0 Ag^{+}/Ag = 0.8 V. (4 Marks)

Course Outcome 2 (CO 2)

1. State Beer Lambert's law (3 Marks)

2. List the important applications of IR spectroscopy (3 Marks)

3. (a) What is Chemical shift? What are factors affecting Chemical shift? How ^{1}H NMR spectrum of CH_3COCH_2Cl interpreted using the concept of chemical shift. (10 Marks)

(b) Calculate the force constant of HF molecule, if it shows IR absorption at 4138 cm^{-1}. Given that atomic masses of hydrogen and fluorine are 1u and 19u respectively. (4 Marks)

Course Outcome 3 (CO 3):

1. Distinguish between TGA and DTA (3 Marks)

2. Give two differences between GSC and GLC (3 Marks)

3. (a) Explain the principle, instrumentation and procedure of HPLC (10 Marks)

(b) Interpret TGA of $CaC_2O_4 . H_2O$ (4 Marks)

Course Outcome 4 (CO 4):

1. Explain the geometrical isomerism in double bonds (3 Marks)

2. What are the rules of assigning R-S notation? (3 Marks)

3. (a) What are conducting polymers? How it is classified? Give the preparation of polyaniline (10 Marks)

(b) Draw the stereoisomers possible for CH_3-$(CHOH)_2$-COOH (4 Marks)

Course Outcome 5 (CO 5):

1. What is degree of hardness? (3 Marks)

2. Define BOD and COD (3 Marks)

3. (a) Explain the EDTA estimation of hardness (10 Marks)

(b) Standard hard water contains 20 g of CaCO3 per liter,50 mL of this required 30mL of EDTA solution, 50mL of sample water required 20mL of EDTA solution. 50mL sample water after boiling required 14 mL EDTA solution. Calculate the temporary hardness of the given sample of water, in terms of ppm. (4 Marks)

MODEL QUESTION PAPER

Total Pages:

Reg No.:________________ Name:____________________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIRST SEMESTER B.TECH DEGREE EXAMINATION

Course Code: CYT100,

Course Name: ENGINEERING CHEMISTRY

Max. Marks: 100 Duration: 3 Hours

PART A

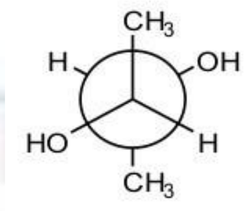
Answer all questions, each carries 3 marks

		Marks
1	What is potentiometric titration? How the end point is determined graphically?	(3)
2	What is Galvanic series? How is it different from electrochemical series?	(3)
3	Which of the following molecules can give IR absorption? Give reason? (a) O_2 (b) H_2O (c) N_2 (d) HCl	(3)
4	Which of the following molecules show UV-Visible absorption? Give reason. (a) Ethane (b) Butadiene (c) Benzene	(3)

5 What are the visualization techniques used in TLC? (3)

6 Write the three important applications of nanomaterials. (3)

7 Draw the Fischer projection formula and find R-S notation of (3)



8 Write the structure of a) Polypyrroleb) Kevlar. (3

9 What is break point chlorination? (3)

10 What is reverse osmosis? (3)

PART B

Answer any one full question from each module, each question carries 14 marks

Module 1

11 a) Give the construction of Li-ion cell. Give the reactions that take place at the electrodes during charging and discharging. What happens to anodic material when the cell is 100% charged. (10)

b) Calculate the standard electrode potential of Cu, if its electrode potential at 25 °C is 0.296 V and the concentration of Cu^{2+} is 0.015 M. (4)

OR

12 a) Explain the mechanism of electrochemical corrosion of iron in oxygen rich and oxygen deficient acidic and basic environments. (10)

b) Given below are reduction potentials of some species (4)

$MnO_4^- + 8H^+ + 5e \rightarrow Mn^{2+} + 4H_2O; E^0 = +1.51$ V

$Cl_2 + 2e \rightarrow 2Cl^-$; $E^0 = +1.36$ V

$S_2O_8^{2-} + 2e \rightarrow 2SO_4^{2-}$; $E^0 = +1.98$ V

Use the above data to examine whether the acids, dil. HCl and dil. H_2SO_4, can be used to provide acid medium in redox titrations involving $KMnO_4$.

Module 2

13 a) What is spin-spin splitting? Draw the NMR spectrum of (i) CH_3 CH_2CH_2 Br (ii) $CH_3CH(Br)CH_3$ Explain how NMR spectrum can be used to identify the two isomers. (10)

b) A dye solution of concentration 0.08M shows absorbance of 0.012 at 600 nm; while a test solution of same dye shows absorbance of 0.084 under same conditions. Find the concentration of the test solution. (4)

OR

14 a) Explain the basic principle of UV-Visible spectroscopy. What are the possible electronic transitions? Explain with examples. (10)

b) Sketch the vibrational modes of CO_2 and H_2O. Which of them are IR active? (4)

Module 3

15 a) Explain the principle, instrumentation and procedure involved in gas chromatography. (10)

b) Explain the DTA of $CaC_2O_4.H_2O$ with a neat sketch. (4)

OR

16 a) Explain the various chemical methods used for the synthesis of nanomaterial (10)

b) How TGA is used to analyse the thermal stability of polymers? (4)

Module 4

17 a) What are conformers? Draw the*cis* and *trans*isomers of 1, 3-dimethylcylohexane. Which conformer (chair form) is more stable in each case? (10)

b) What is ABS? Give properties and applications. (4)

OR

18 a) Explain the various structural isomers with suitable example. (10)

b) What is OLED? Draw a labelled diagram. (4)

Module 5

19 a) What are ion exchange resins? Explain ion exchange process for removal of hardness of water? How exhausted resins are regenerated? (10)

b) 50 mL sewage water is diluted to 2000 mL with dilution water; the initial dissolved oxygen was 7.7 ppm. The dissolved oxygen level after 5 days of incubation was 2.4 ppm. Find the BOD of the sewage. (4)

OR

20 a) What are the different steps in sewage treatment? Give the flow diagram. Explain the working of trickling filter. (10)

b) Calculate the temporary and permanent hardness of a water sample which contains $[Ca^{2+}]$ = 160 mg/L, $[Mg^{2+}]$ = 192 mg/L and $[HCO_3^-]$ = 122 mg/L. (4)

Syllabus

Module 1

Electrochemistry and Corrosion

Introduction - Differences between electrolytic and electrochemical cells - Daniel cell - redox reactions - cell representation. Different types of electrodes (brief) - Reference electrodes - SHE - Calomel electrode - Glass Electrode - Construction and Working. Single electrode potential - definition - Helmholtz electrical double layer -Determination of E^0 using calomel electrode.Determination of pH using glass electrode.Electrochemical series and its applications. Free energy and EMF - Nernst Equation - Derivation - single electrode and cell (Numericals) -Application - Variation of emf with temperature. Potentiometric titration - Introduction -Redox titration only.Lithiumion cell - construction and working.Conductivity- Measurement of conductivity of a solution (Numericals).

Corrosion-Electrochemicalcorrosion – mechanism. Galvanic series- cathodic protection - electroless plating –Copper and Nickel plating.

Module 2

Spectroscopic Techniques and Applications

Introduction- Types of spectrum - electromagnetic spectrum - molecular energy levels - Beer Lambert's law (Numericals). UV-Visible Spectroscopy – Principle - Types of electronic transitions - Energy level diagram of ethane, butadiene, benzene and hexatriene. Instrumentation of UV-Visible spectrometer and applications.IR-Spectroscopy – Principle - Number of vibrational modes - Vibrational energy states of a diatomic molecule and -Determination of force constant of diatomic molecule (Numericals) –Applications. ^{1}H NMR spectroscopy – Principle - Relation between field strength and frequency - chemical shift - spin-spin splitting (spectral problems) - coupling constant (definition) - applications of NMR- including MRI (brief).

Module 3

Instrumental Methods and Nanomaterials

Thermal analysis –TGA- Principle, instrumentation (block diagram) and applications – TGA of $CaC_2O_4.H_2O$ and polymers. DTA-Principle, instrumentation (block diagram) and applications - DTA of $CaC_2O_4.H_2O$. Chromatographic methods - Basic principles and applications of column and TLC-Retention factor. GC and HPLC-Principle, instrumentation (block diagram) - retention time and applications.

Nanomaterials - Definition - Classification - Chemical methods of preparation - Hydrolysis and Reduction - Applications of nanomaterials - Surface characterisation -SEM – Principle and instrumentation (block diagram).

Module 4

Stereochemistry and Polymer Chemistry

Isomerism-Structural, chain, position, functional, tautomerism and matamerism - Definition with examples - Representation of 3D structures-Newman, Sawhorse, Wedge and Fischer projection of substituted methane and ethane. Stereoisomerism - Geometrical isomerism in double bonds and cycloalkanes (cis-trans and E-Z notations). R-S Notation – Rules and examples - Optical isomerism, Chirality, Enantiomers and Diastereoisomers-Definition with examples.Conformational analysis of ethane, butane, cyclohexane, mono and di methyl substituted cyclohexane.

Copolymers - Definition - Types - Random, Alternating, Block and Graft copolymers - ABS - preparation, properties and applications.Kevlar-preparation, properties and applications.Conducting polymers - Doping -Polyaniline and Polypyrrole - preparation properties and applications. OLED - Principle, construction and advantages.

Module 5

Water Chemistry and Sewage Water Treatment

Water characteristics - Hardness - Types of hardness- Temporary and Permanent - Disadvantages of hard water -Units of hardness- ppm and mg/L -Degree of hardness (Numericals) - Estimation of hardness-EDTA method (Numericals). Water softening methods-Ion exchange process-Principle, procedure and advantages. Reverse osmosis – principle, process and advantages. Municipal water treatment (brief) - Disinfection methods - chlorination, ozone andUV irradiation.

Dissolved oxygen (DO) -Estimation (only brief procedure-Winkler's method), BOD and COD-definition, estimation (only brief procedure) and significance (Numericals). Sewage water treatment - Primary, Secondary and Tertiary - Flow diagram -Trickling filter and UASB process.

Text Books

1. B. L. Tembe, Kamaluddin, M. S. Krishnan, "Engineering Chemistry (NPTEL Web-book)", 2018.

2. P. W. Atkins, "Physical Chemistry", Oxford University Press, 10th edn., 2014.

Reference Books

1. C. N. Banwell, "Fundamentals of Molecular Spectroscopy", McGraw-Hill, 4thedn., 1995.
2. Donald L. Pavia, "Introduction to Spectroscopy", Cengage Learning India Pvt. Ltd., 2015.
3. B. R. Puri, L. R. Sharma, M. S. Pathania, "Principles of Physical Chemistry", Vishal Publishing Co., 47th Edition, 2017.
4. H. H. Willard, L. L. Merritt, "Instrumental Methods of Analysis", CBS Publishers, 7th Edition, 2005.
5. Ernest L. Eliel, Samuel H. Wilen, "Stereo-chemistry of Organic Compounds", WILEY, 2008.
6. Raymond B. Seymour, Charles E. Carraher, "Polymer Chemistry: An Introduction", Marcel Dekker Inc; 4th Revised Edition, 1996.
7. MuhammedArif, Annette Fernandez, Kavitha P. Nair "Engineering Chemistry", Owl Books, 2019.
8. Ahad J., "Engineering Chemistry", Jai Publication, 2019.
9. Roy K. Varghese, "Engineering Chemistry", Crownplus Publishers, 2019.
10. Soney C. George,RinoLaly Jose, "Text Book of Engineering Chemistry", S. Chand & Company Pvt Ltd, 2019.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures (hrs)
1	**Electrochemistry and Corrosion**	**9**
1.1	Introduction - Differences between electrolytic and electrochemical cells- Daniel cell - redox reactions - cell representation. Different types of electrodes (brief) - Reference electrodes- SHE - Calomel electrode - Glass Electrode - Construction and Working.	**2**
1.2	Single electrode potential – definition - Helmholtz electrical double layer - Determination of E^0 using calomel electrode. Determination of pH using glass electrode. Electrochemical series and its applications. Free energy and EMF - Nernst Equation – Derivation - single electrode and cell (Numericals) -Application -Variation of emf with temperature.	**3**
1.3	Potentiometric titration - Introduction -Redox titration only. Lithiumion cell - construction and working. Conductivity- Measurement of conductivity of a solution (Numericals).	**2**
1.4	Corrosion-Electrochemicalcorrosion – mechanism. Galvanic series- cathodic protection - electroless plating –Copper and Nickel plating.	**2**
2	**Spectroscopic Techniques and Applications**	**9**
2.1	Introduction- Types of spectrum - electromagnetic spectrum - molecular energy levels - Beer Lambert's law (Numericals).	**2**
2.2	UV-Visible Spectroscopy – Principle - Types of electronic transitions - Energy level diagram of ethane, butadiene, benzene and hexatriene. Instrumentation of UV-Visible spectrometer and applications.	**2**
2.3	IR-Spectroscopy – Principle - Number of vibrational modes -Vibrational energy states of a diatomic molecule and -Determination of force constant of diatomic molecule (Numericals) –Applications.	**2**
2.4	^1H NMR spectroscopy – Principle - Relation between field strength and frequency - chemical shift - spin-spin splitting (spectral problems) - coupling constant (definition) - applications of NMR- including MRI (brief).	**3**
3	**Instrumental Methods and Nanomaterials**	**9**
3.1	Thermal analysis –TGA- Principle, instrumentation (block diagram) and applications – TGA of $CaC_2O_4.H_2O$ and polymers. DTA-Principle, instrumentation (block diagram) and applications - DTA of $CaC_2O_4.H_2O$.	**2**

3.2	Chromatographic methods - Basic principles and applications of column and TLC-Retention factor.	**2**
3.3	GC and HPLC-Principle, instrumentation (block diagram) - retention time and applications.	**2**
3.4	Nanomaterials - Definition - Classification - Chemical methods of preparation - Hydrolysis and Reduction - Applications of nanomaterials - Surface characterisation -SEM – Principle and instrumentation (block diagram).	**3**
4	**Stereochemistry and Polymer Chemistry**	**9**
4.1	Isomerism-Structural, chain, position, functional, tautomerism and matamerism - Definition with examples - Representation of 3D structures-Newman, Sawhorse, Wedge and Fischer projection of substituted methane and ethane. Stereoisomerism - Geometrical isomerism in double bonds and cycloalkanes (cis-trans and E-Z notations).	**2**
4.2	R-S Notation – Rules and examples - Optical isomerism, Chirality, Enantiomers and Diastereoisomers-Definition with examples.	**1**
4.3	Conformational analysis of ethane, butane, cyclohexane, mono and di methyl substituted cyclohexane.	**2**
4.4	Copolymers - Definition - Types - Random, Alternating, Block and Graft copolymers - ABS - preparation, properties and applications. Kevlar-preparation, properties and applications. Conducting polymers - Doping -Polyaniline and Polypyrrole - preparation properties and applications. OLED - Principle, construction and advantages.	**4**
5	**Water Chemistry and Sewage Water Treatment**	**9**
5.1	Water characteristics - Hardness - Types of hardness- Temporary and Permanent - Disadvantages of hard water -Units of hardness- ppm and mg/L -Degree of hardness (Numericals) - Estimation of hardness-EDTA method (Numericals). Water softening methods-Ion exchange process-Principle, procedure and advantages. Reverse osmosis – principle, process and advantages.	**3**
5.2	Municipal water treatment (brief) - Disinfection methods - chlorination, ozone andUV irradiation.	**2**
5.3	Dissolved oxygen (DO) -Estimation (only brief procedure-Winkler's method), BOD and COD-definition, estimation (only brief procedure) and significance (Numericals).	**2**
5.4	Sewage water treatment - Primary, Secondary and Tertiary - Flow diagram - Trickling filter and UASB process.	**2**

EST 110	ENGINEERING GRAPHICS	CATEGORY	L	T	P	CREDIT	Year of Introduction
		ESC	2	0	2	3	2019

Preamble: To enable the student to effectively perform technical communication through graphical representation as per global standards.

Prerequisite: NIL

Course Outcomes: After the completion of the course the student will be able to

CO 1	Draw the projection of points and lines located in different quadrants
CO 2	Prepare multiview orthographic projections of objects by visualizing them in different positions
CO 3	Draw sectional views and develop surfaces of a given object
CO 4	Prepare pictorial drawings using the principles of isometric and perspective projections to visualize objects in three dimensions.
CO 5	Convert 3D views to orthographic views
CO 6	Obtain multiview projections and solid models of objects using CAD tools

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3											
CO 2	3											
CO 3	3	1										
CO 4	3									1		
CO 5	3									2		
CO 6	3				3					3		

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination (100 Marks)
	Test 1 (15 Marks)	Test 2 (15 Marks)	
Remember			
Understand	5		20
Apply	10	10	80
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE (Marks)	ESE (Marks)	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks

CIA for section A carries 25 marks (15 marks for 1 test and Class work 10 marks)

CIA for section B carries 15 marks (10 marks for 1 test and Class work 5 marks)

End Semester Examination Pattern:

ESE will be of 3 hour duration on A4 size answer booklet and will be for 100 marks. The question paper shall contain two questions from each module of Section A only. Student has to answer any one question from each module. Each question carries 20 marks.

Course Level Assessment Questions

(Questions may be framed based on the outline given under each course outcome)

Course Outcome 1 (CO1):

1. Locate points in different quadrants as per given conditions.
2. Problems on lines inclined to both planes .
3. Find True length, Inclinations and Traces of lines.

Course Outcome 2 (CO2)

1. Draw orthographic views of solids and combination solids
2. Draw views of solids inclined to any one reference plane.
3. Draw views of solids inclined to both reference planes.

Course Outcome 3 (CO3):

1. Draw views of solids sectioned by a cutting plane
2. Find location and inclination of cutting plane given true shape of the section
3. Draw development of lateral surface of solids and also its sectioned views

Course Outcome 4 (CO4):

1. Draw Isometric views/projections of soilds
2. Draw Isometric views/projections of combination of soilds
3. Draw Perspective views of Soilds

Course Outcome 5 (CO5):

1. Draw Orthographic views of solids from given three dimensional view

Course Outcome 6 (CO6):

1. Draw the given figure including dimensions using 2D software
2. Create 3D model using modelling software from the given orthographic views or 3D figure or from real 3D objects

Model Question paper

QP CODE: PAGES:3

Reg No:_______________

Name :________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY FIRST SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: EST 110

ENGINEERING GRAPHICS

Max.Marks:100 **Duration: 3 Hours**

PART A

Answer all Questions. Each question carries 3 Marks

Instructions: Retain necessary Construction lines
Show necessary dimensions
Answer any ONE question from each module
Each question carries 20 marks

MODULE I

1. The end point A of a line is 20mm above HP and 10mm in front of VP. The other end of the line is 50mm above HP and 15mm behind VP. The distance between the end projectors is 70mm. Draw the projections of the line. Find the true length and true inclinations of the line with the principal planes. Also locate the traces of the line.
2. One end of a line is 20mm from both the principal planes of projection. The other end of the line is 50mm above HP and 40mm in front of VP. The true length of the line is 70mm. Draw the projections of the line. Find its apparent inclinations, elevation length and plan length. Also locate its traces.

MODULE II

3. A pentagonal pyramid of base side 25mm and height 40mm, is resting on the ground on one of its triangular faces. The base edge of that face is inclined 30^{o} to VP. Draw the projections of the solid.

4. A hexagonal prism has side 25mm and height 50mm has a corner of its base on the ground and the long edge containing that corner inclined at 30^o to HP and 45^o to VP. Draw the projections of the solid.

MODULE III

5. A triangular prism of base side 40mm and height 70mm is resting with its base on the ground and having an edge of the base perpendicular to VP. Section the solid such that the true shape of the section is a trapezium of parallel sides 30mm and 10mm. Draw the projections showing the true shape. Find the inclination of the cutting plane with the ground plane.

6. Draw the development of a pentagonal pyramid of base side 30mm and height 50mm. A string is wound from a corner of the base round the pyramid and back to the same point through the shortest distance. Show the position of the string in the elevation and plan.

MODULE IV

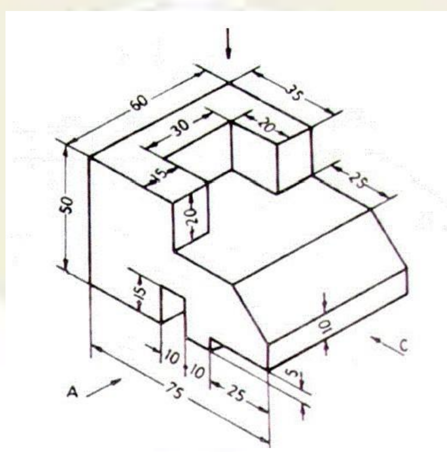
7. The frustum of a cone has base diameter 50mm and top diameter 40mm has a height of 60mm. It is paced centrally on top of a rectangular slab of size 80x60mm and of thickness 20mm. Draw the isometric view of the combination.

8. A hexagonal prism has base side 35mm and height 60mm. A sphere of diameter 40mm is placed centrally on top of it. Draw the isometric projection of the combination.

MODULE V

9. Draw the perspective view of a pentagonal prism, 20mm side and 45mm long lying on one of its rectangular faces on the ground and having its axis perpendicular to picture plane. One of its pentagonal faces touches the picture plane and the station point is 50mm in front of PP, 25mm above the ground plane and lies in a central plane, which is 70mm to the left of the center of the prism.

10. Draw three orthographic views with dimensions of the object shown in figure below.



(20X5=100)

Time : 3 hours **EST110 ENGINEERING GRAPHICS** **Max. Marks: 100**

SCHEME OF VALUATION

1. Locating the points and drawing the projections of the line – 4 marks
   Finding true length by any one method – 6 marks
   Finding true inclination with VP – 2 marks
   Finding true inclination with HP – 2 marks
   Locating horizontal trace – 2 marks
   Locating vertical trace – 2 marks
   Dimensioning and neatness – 2 marks

   Total = 20 marks

2. Locating the points and drawing true length of the line – 4 marks
   Finding projections by any method – 6 marks
   Finding length of elevation and plan – 2 marks
   Finding apparent inclinations – 2 marks
   Locating horizontal trace – 2 marks
   Locating vertical trace – 2 marks
   Dimensioning and neatness – 2 marks

   Total = 20 marks

3. Drawing initial position plan and elevation – 4 marks
   First inclination views – 4 marks
   Second inclination views -8 marks
   Marking invisible edges – 2 marks
   Dimensioning and neatness – 2 marks

   Total = 20 marks

   (Any one method or combination of methods for solving can be used.
   If initial position is wrong then maximum 50% marks may be allotted for the answer)

4. Drawing initial position plan and elevation – 4 marks
   First inclination views – 4 marks
   Second inclination views -8 marks
   Marking invisible edges – 2 marks
   Dimensioning and neatness – 2 marks

   Total = 20 marks

   (Any one method or combination of methods for solving can be used
   If initial position is wrong then maximum 50% marks may be allotted for the answer)

5. Drawing initial position plan and elevation – 4 marks
   Locating section plane as per given condition – 5 marks
   Drawing true shape -5 marks
   Finding inclination of cutting plane – 2 marks
   Dimensioning and neatness – 2 marks

   Total = 20 marks

6. Drawing initial position plan and elevation – 4 marks
   Development of the pyramid – 6 marks

Locating string in development -2 marks
Locating string in elevation – 3 marks
Locating string in plan – 3 marks
Dimensioning and neatness – 2 marks

Total = 20 marks

7. Drawing initial positions – 4 marks
Isometric View of Slab -6 marks
Isometric View of Frustum – 10 marks
Dimensioning and neatness – 2 marks

Total = 20 marks

(Initial position is optional, hence redistribute if needed.
Reduce 4 marks if Isometric scale is taken)

8. Drawing initial positions – 4 marks
Isometric scale – 4 marks
Isometric projection of prism -5 marks
Isometric projection of sphere – 5 marks
Dimensioning and neatness – 2 marks

Total = 20 marks

(Initial position is optional, hence redistribute if needed.

9. Drawing the planes and locating the station point – 4 marks
Locating elevation points – 2 marks
Locating plan points – 2 marks
Drawing the perspective view – 10 marks
Dimensioning and neatness – 2 marks

Total = 20 marks

10. Drawing the elevation – 8marks
Drawing the plan – 4 marks
Drawing the side view – 4 marks
Marking invisible edges – 2 marks
Dimensioning and neatness – 2 marks

Total = 20 marks

SYLLABUS

General Instructions:

- First angle projection to be followed
- Section A practice problems to be performed on A4 size sheets
- Section B classes to be conducted on CAD lab

SECTION A

Module 1

Introduction : Relevance of technical drawing in engineering field. Types of lines, Dimensioning, BIS code of practice for technical drawing.

Orthographic projection of Points and Lines: Projection of points in different quadrants, Projection of straight lines inclined to one plane and inclined to both planes. Trace of line. Inclination of lines with reference planes True length of line inclined to both the reference planes.

Module 2

Orthographic projection of Solids: Projection of Simple solids such as Triangular, Rectangle, Square, Pentagonal and Hexagonal Prisms, Pyramids, Cone and Cylinder. Projection of solids in simple position including profile view. Projection of solids with axis inclined to one of the reference planes and with axis inclined to both reference planes.

Module 3

Sections of Solids: Sections of Prisms, Pyramids, Cone, Cylinder with axis in vertical position and cut by different section planes. True shape of the sections. Also locating the section plane when the true shape of the section is given.

Development of Surfaces: Development of surfaces of the above solids and solids cut by different section planes. Also finding the shortest distance between two points on the surface.

Module 4

Isometric Projection: Isometric View and Projections of Prisms, Pyramids, Cone , Cylinder, Frustum of Pyramid, Frustum of Cone, Sphere, Hemisphere and their combinations.

Module 5

Perspective Projection: Perspective projection of Prisms and Pyramids with axis perpendicular to the ground plane, axis perpendicular to picture plane.

Conversion of Pictorial Views: Conversion of pictorial views into orthographic views.

SECTION B

(To be conducted in CAD Lab)

Introduction to Computer Aided Drawing: Role of CAD in design and development of new products, Advantages of CAD. Creating two dimensional drawing with dimensions using suitable software. (Minimum 2 exercises mandatory)

Introduction to Solid Modelling: Creating 3D models of various components using suitable modelling software. (Minimum 2 exercises mandatory)

Text Books

1. Bhatt, N.D., Engineering Drawing, Charotar Publishing House Pvt. Ltd.
2. John, K.C. Engineering Graphics, Prentice Hall India Publishers.

Reference Books

1. Anilkumar, K.N., Engineering Graphics, Adhyuth narayan Publishers
2. Agrawal, B. And Agrawal, C.M., Engineering Darwing, Tata McGraw Hill Publishers.
3. Benjamin, J., Engineering Graphics, Pentex Publishers- 3rd Edition, 2017
4. Duff, J.M. and Ross, W.A., Engineering Design and Visualisation, Cengage Learning.
5. Kulkarni, D.M., Rastogi, A.P. and Sarkar, A.K., Engineering Graphics with AutoCAD, PHI.
6. Luzaddff, W.J. and Duff, J.M., Fundamentals of Engineering Drawing, PHI.
7. Varghese, P.I., Engineering Graphics, V I P Publishers
8. Venugopal, K., Engineering Drawing and Graphics, New Age International Publishers.

Course Contents and Lecture Schedule

No	**SECTION A**	No. of Hours
1	**MODULE I**	
1.1	Introduction to graphics, types of lines, Dimensioning	1
1.2	Concept of principle planes of projection, different quadrants, locating points on different quadrants	2
1.3	Projection of lines, inclined to one plane. Lines inclined to both planes, trapezoid method of solving problems on lines.	2
1.4	Problems on lines using trapezoid method	2
1.5	Line rotation method of solving, problems on line rotation method	2
2	**MODULE II**	
2.1	Introduction of different solids, Simple position plan and elevation of solids	2
2.2	Problems on views of solids inclined to one plane	2
2.3	Problems on views of solids inclined to both planes	2
2.4	Practice problems on solids inclined to both planes	2

3	**MODULE III**	
3.1	Introduction to section planes. AIP and AVP. Principle of locating cutting points and finding true shape	2
3.2	Problems on sections of different solids	2
3.3	Problems when the true shape is given	2
3.4	Principle of development of solids, sectioned solids	2
4	**MODULE IV**	
4.1	Principle of Isometric View and Projection, Isometric Scale. Problems on simple solids	2
4.2	Isometric problems on Frustum of solids, Sphere and Hemisphere	2
4.3	Problems on combination of different solids	2
5	**MODULE V**	
5.1	Introduction to perspective projection, different planes, station point etc. Perspective problems on pyramids	2
5.2	Perspective problems on prisms	2
5.3	Practice on conversion of pictorial views into orthographic views	2
	SECTION B (To be conducted in CAD lab)	
1	Introduction to CAD and software. Familiarising features of 2D software. Practice on making 2D drawings	2
2	Practice session on 2D drafting	2
3	Introduction to solid modelling and software	2
4	Practice session on 3D modelling	2

EST 120	BASICS OF CIVIL & MECHANICAL ENGINEERING	CATEGORY	L	T	P	CREDIT	YEAR OF INTRODUCTION
		ESC	4	0	0	4	2019

Preamble:

Objective of this course is to provide an insight and inculcate the essentials of Civil Engineering discipline to the students of all branches of Engineering and to provide the students an illustration of the significance of the Civil Engineering Profession in satisfying the societal needs.

To introduce the students to the basic principles of mechanical engineering

Prerequisite: NIL

Course Outcomes: After completion of the course, the student will be able to

CO 1	Recall the role of civil engineer in society and to relate the various disciplines of Civil Engineering.
CO 2	Explain different types of buildings, building components, building materials and building construction
CO 3	Describe the importance, objectives and principles of surveying.
CO 4	Summarise the basic infrastructure services MEP, HVAC, elevators, escalators and ramps
CO 5	Discuss the Materials, energy systems, water management and environment for green buildings.
CO 6	Analyse thermodynamic cycles and calculate its efficiency
CO 7	Illustrate the working and features of IC Engines
CO 8	Explain the basic principles of Refrigeration and Air Conditioning
CO 9	Describe the working of hydraulic machines
CO 10	Explain the working of power transmission elements
CO 11	Describe the basic manufacturing, metal joining and machining processes

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO1	3	-	-	-	-	3	2	2	-	-	-	-
CO2	3	2	-	1	3	-	-	3	-	-	-	-
CO3	3	2	-	-	3	-	-	-	2	-	-	-

CO4	3	2	-	-	3	-	-	-	2	-	-	-
CO5	3	2	-	-	3	2	3	-	2	-	-	-
CO6	3	2										
CO7	3	1										
CO8	3	1										
CO9	3	2										
CO10	3	1										
CO11	3											

Assessment Pattern

	Basic Civil Engineering			**Basic Mechanical Engineering**		
Bloom's Category	**Continuous Assessment**		**End Semester Examination (marks)**	**Continuous Assessment**		**End Semester Examination (marks)**
	Test 1 marks	**Test 2 marks**		**Test 1 marks**	**Test 2 marks**	
Remember	5	5	10	7.5	7.5	15
Understand	20	20	40	12.5	12.5	25
Apply				5	5	10
Analyse						
Evaluate						
Create						

Mark distribution

Total Marks	**CIE (Marks)**	**ESE (Marks)**	**ESE Duration**
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern:

There will be two parts; Part I – Basic Civil Engineering and Part II – Basic Mechanical Engineering. Part I and PART II carries 50 marks each. For the end semester examination, part I contain 2 parts -

Part A and Part B. Part A contain 5 questions carrying 4 marks each (not exceeding 2 questions from each module). Part B contains 2 questions from each module out of which one to be answered. Each question carries 10 mark and can have maximum 2 sub-divisions. The pattern for end semester examination for part II is same as that of part I. **However, student should answer both part I and part 2 in separate answer booklets.**

Course Level Assessment Questions:

Course Outcome CO1: *To recall the role of civil engineer in society and to relate the various disciplines of Civil Engineering.*

1.Explain relevance of Civil engineering in the overall infrastructural development of the country.
Course outcome 2 (CO2) (One question from each module and not more than two)

Explain different types of buildings, building components, building materials and building construction

1. Discuss the difference between plinth area and carpet area.

Course outcome 3 (CO3) (One question from each module and not more than two)

Describe the importance, objectives and principles of surveying.

1. Explain the importance of surveying in Civil Engineering

Course outcome 4 (CO4) (One question from each module and not more than two)

Summarise the basic infrastructure services MEP, HVAC, elevators, escalators and ramps

1. Explain the civil engineering aspects of elevators, escalators and ramps in buildings

Course outcome 5 (CO5) (One question from each module and not more than two)

Discuss the Materials, energy systems, water management and environment for green buildings.

1. Discuss the relevance of Green building in society

Section II *Answer any 1 full question from each module. Each full question carries 10 marks*

Course Outcome 1 (CO1) (Two full question from each module and each question can have maximum 2 sub-divisions)

To recall the role of civil engineer in society and to relate the various disciplines of Civil Engineering

CO Questions

1. a List out the types of building as per occupancy. Explain any two, each in about five sentences.
b. Discuss the components of a building with a neat figure.

2. a. What are the major disciplines of civil engineering and explain their role in the infrastructural framework.

b. Explain the role of NBC, KBR & CRZ norms in building rules and regulations prevailing in our country.

Course Outcome 2 (CO2) & Course Outcome 3 (CO3) (Two full question from each module and each question can have maximum 2 sub-divisions)

Explain different types of buildings, building components, building materials and building construction & Describe the importance, objectives and principles of surveying.

<u>CO Questions</u>

1. **a.** What are the different kinds of cement available and what is their use.
   b. List the properties of good building bricks. Explain any five.
2. a. List and explain any five modern construction materials used for construction.
   b. Explain the objectives and principles of surveying

Course outcome 4 (CO4) & Course outcome 5 (CO5) (Two full question from each module and each question can have maximum 2 sub-divisions)

Summarise the basic infrastructure services MEP, HVAC, elevators, escalators and ramps & Discuss the Materials, energy systems, water management and environment for green buildings.

<u>CO Questions</u>

1. **a**. Draw the elevation and plan of one brick thick wall with English bond
   b. Explain the energy systems and water management in Green buildings

2. **a.** Draw neat sketch of the following foundations: (i) Isolated stepped footing; (ii) Cantilever footing; and (iii) Continuous footing.

   b. Discuss the civil engineering aspect of MEP and HVAC in a commercial building

Course Outcome 6 (CO6):

1. In an air standard Otto cycle the compression ratio is 7 and compression begins at 35^{o}C, 0.1 MPa. The maximum temperature of the cycle is 1100^{o}C. Find
   i) Heat supplied per kg of air,
   ii) Work done per kg of air,
   iii) Cycle efficiency
   Take Cp = 1.005 kJ/kgK and Cv=0.718 kJ/kgK
2. A Carnot cycle works with adiabatic compression ratio of 5 and isothermal expansion ratio of 2. The volume of air at the beginning of isothermal expansion is 0.3 m^3. If the maximum temperature and pressure is limited to 550K and 21 bar, determine the minimum temperature in the cycle and efficiency of the cycle.
3. In an ideal diesel cycle, the temperature at the beginning and end of compression is 65^{o}C and 620^{o}C respectively. The temperature at the beginning and end of the expansion is 1850^{o}C and 850 ^{o}C. Determine the ideal efficiency of the cycle.

4. Explain the concepts of CRDI and MPFI in IC Engines.

Course Outcome 7 (CO7)

1. With the help of a neat sketch explain the working of a 4 stroke SI engine
2. Compare the working of 2 stroke and 4 stroke IC engines
3. Explain the classification of IC Engines.

Course Outcome 8(CO8):

1. Explain the working of vapour compression refrigeration system.
2. With the help of suitable sketch explain the working of a split air conditioner.
3. Define: COP, specific humidity, relative humidity and dew point temperature.

Course Outcome 9 (CO9):

1. Explain the working of a single stage centrifugal pump with sketches.
2. With the help of a neat sketch, explain the working of a reciprocating pump.
3. A turbine is to operate under a head of 25 m at 200 rpm. The discharge is 9 m^3/s. If the overall efficiency of the turbine is 90%. Determine the power developed by the turbine.

Course Outcome 10 (CO10):

1. Explain the working of belt drive and gear drive with the help of neat sketches
2. Explain a single plate clutch.
3. Sketch different types of gear trains and explain.

Course Outcome 11 (CO11):

1. Describe the operations which can be performed using drilling machine.
2. Explain the functions of runners and risers used in casting.
3. With a neat sketch, explain the working and parts of a lathe.

Model Question Paper

QP CODE: **EST120** page:3

Reg No:___________________

Name:______________________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY FIRST SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: EST 120

Course Name: BASICS OF CIVIL AND MECHANICAL ENGINEERING

Max. Marks: 100 Duration: 3 hours

Answer both part I and part 2 in separate answer booklets

PART I: BASIC CIVIL ENGINEERING

PART A

(Answer all questions. Each question carries 4 marks)

1. Explain relevance of Civil engineering in the overall infrastructural development of the country.
2. Discuss the difference between plinth area and carpet area.
3. Explain different types of steel with their properties.
4. What are the different kinds of cement available and what is their use?
5. Define bearing capacity of soil.

(5 x 4 = 20)

Part B

Answer one full question from each module.

MODULE I

6a. List out the types of building as per occupancy. Explain any two, each in about five sentences. (5)

b. Discuss the components of a building with a neat figure. (5)

OR

7a. What are the major disciplines of civil engineering and explain their role in the infrastructural framework. (5)

b. Explain the role of NBC, KBR & CRZ norms in building rules and regulations prevailing in our country. (5)

MODULE II

8a. What are the different kinds of cement available and what is their use. (5)

b. List the properties of good building bricks. Explain any five. (5)

OR

9a. List and explain any five modern construction materials used for construction. (5)

b. Explain the objectives and principles of surveying (5)

MODULE III

10a. Draw the elevation and plan of one brick thick wall with English bond (5)

b. Explain the energy systems and water management in Green buildings (5)

OR

11a. Draw neat sketch of the following foundations: (i) Isolated stepped footing; (ii) Cantilever footing; and (iii) Continuous footing. (5)

b. Discuss the civil engineering aspect of MEP and HVAC in a commercial building (5)

[10 x 3 = 30]

PART II: BASIC MECHANICAL ENGINEERING

PART A

Answer all questions. Each question carries 4 marks

1. Sketch the P-v and T-s diagram of a Carnot cycle and List the processes.
2. Illustrate the working of an epicyclic gear train.
3. Explain cooling and dehumidification processes.
4. Differentiate between soldering and brazing.
5. Explain the principle of Additive manufacturing.

4 x 5 = 20 marks

Part B

Answer one full question from each module.

MODULE I

6. In an air standard Otto cycle the compression ratio is 7 and compression begins at 35^{o}C, 0.1MPa. The maximum temperature of the cycle is 1100^{o}C. Find

   i) Heat supplied per kg of air,

   ii) Work done per kg of air,

   iii)Cycle efficiency

   Take C_p = 1.005 kJ/kgK and C_v=0.718 kJ/kgK — 10 marks

OR

7. a) Explain the working of a 4 stroke SI engine with neat sketches. — 7 marks

   b) Explain the fuel system of a petrol engine. — 3 marks

MODULE II

8. a) Explain the working of a vapour compression system with help of a block diagram. — 7 marks

   b) Define: Specific humidity, relative humidity and dew point temperature. — 3 marks

OR

9. With the help of a neat sketch, explain the working of a centrifugal pump. — 10 marks

MODULE III

10. Explain the two high, three high, four high and cluster rolling mills with neat sketches. — 10 marks

OR

11. a) Describe the arc welding process with a neat sketch. — 6 marks

    b) Differentiate between up-milling and down-milling operations. — 4 marks

SYLLABUS

Module 1

General Introduction to Civil Engineering: Relevance of Civil Engineering in the overall infrastructural development of the country. Responsibility of an engineer in ensuring the safety of built environment. Brief introduction to major disciplines of Civil Engineering like Transportation Engineering, Structural Engineering, Geo-technical Engineering, Water Resources Engineering and Environmental Engineering.

Introduction to buildings: Types of buildings, selection of site for buildings, components of a residential building and their functions.

Building rules and regulations: Relevance of NBC, KBR & CRZ norms (brief discussion only).

Building area: Plinth area, built up area, floor area, carpet area and floor area ratio for a building as per KBR.

Module 2

Surveying: Importance, objectives and principles.

Construction materials, Conventional construction materials**:** types, properties and uses of building materials: bricks, stones, cement, sand and timber

Cement concrete: Constituent materials, properties and types.

Steel: Steel sections and steel reinforcements, types and uses.

Modern construction materials:- Architectural glass, ceramics, Plastics, composite materials, thermal and acoustic insulating materials, decorative panels, waterproofing materials. Modern uses of gypsum, pre-fabricated building components (brief discussion only).

Module 3

Building Construction: Foundations: Bearing capacity of soil (definition only), functions of foundations, types – shallow and deep (brief discussion only). Load bearing and framed structures (concept only).

Brick masonry: - Header and stretcher bond, English bond & Flemish bond random rubble masonry.

Roofs and floors: - Functions, types; flooring materials (brief discussion only).

Basic infrastructure services: MEP, HVAC, elevators, escalators and ramps (Civil Engineering aspects only), fire safety for buildings.

Green buildings:- Materials, energy systems, water management and environment for green buildings. (brief discussion only).

Module 4

Analysis of thermodynamic cycles: Carnot, Otto, Diesel cycles, Derivation of efficiency of these cycles, Problems to calculate heat added, heat rejected, net work and efficiency. IC Engines: CI, SI, 2-Stroke, 4-Stroke engines. Listing the parts of different types of IC Engines. Efficiencies of IC Engines(Definitions only), Air, Fuel, cooling and lubricating systems in SI and CI Engines, CRDI, MPFI. Concept of hybrid engines.

Module 5

Refrigeration: Unit of refrigeration, reversed Carnot cycle,COP, vapour compression cycle (only description and no problems); Definitions of dry, wet & dew point temperatures, specific humidity and relative humidity, Cooling and dehumidification, Layout of unit and central air conditioners.

Description about working with sketches of: Reciprocating pump, Centrifugal pump, Pelton turbine, Francis turbine and Kaplan turbine. Overall efficiency, Problems on calculation of input and output power of pumps and turbines (No velocity triangles)

Description about working with sketches of: Belt and Chain drives, Gear and Gear trains, Single plate clutches.

Module 6

Manufacturing Process: Basic description of the manufacturing processes – Sand Casting, Forging, Rolling, Extrusion and their applications.

Metal Joining Processes: List types of welding, Description with sketches of Arc Welding, Soldering and Brazing and their applications

Basic Machining operations: Turning, Drilling, Milling and Grinding.

Description about working with block diagram of: Lathe, Drilling machine, Milling machine, CNC Machine. Principle of CAD/CAM, Rapid and Additive manufacturing.

Text Books:

1. Rangwala, S. C., Essentials of Civil Engineering, Charotar Publishing House
2. Mckay, W.B. and Mckay, J. K., Building Construction, Volumes 1 to 4, Pearson India Education Services

References Books:

1. Chen W.F and Liew J Y R (Eds), The Civil Engineering Handbook. II Edition CRC Press (Taylor and Francis)
2. Chudley, R and Greeno R, Building construction handbook, Addison Wesley, Longman group, England
3. Chudley, R, Construction Technology, Vol. I to IV, Longman group, England Course Plan
4. Kandya A A, Elements of Civil Engineering, Charotar Publishing house
5. Mamlouk, M. S., and Zaniewski, J. P., Materials for Civil and Construction Engineering, Pearson Publishers
6. Rangwala S.C and Dalal K B Building Construction Charotar Publishing house
7. Clifford, M., Simmons, K. and Shipway, P., An Introduction to Mechanical Engineering Part I - CRC Press
8. Roy and Choudhary, Elements of Mechanical Engineering, Media Promoters &Publishers Pvt. Ltd., Mumbai.
9. Sawhney, G. S., Fundamentals of Mechanical Engineering, PHI
10. G Shanmugam, M S Palanichamy, Basic Civil and Mechanical Engineering, McGraw Hill Education; First edition, 2018
11. Benjamin,J.,Basic Mechanical Engineering,Pentex Books,9th Edition,2018
12. Balachandran, P.Basic Mechanical Engineering,Owl Books

Course Contents and Lecture Schedule:

No	Topic	Course outcomes addressed	No. of Lectures
1	**Module I**		**Total: 7**
1.1	*General Introduction to Civil Engineering*: Relevance of Civil Engineering in the overall infrastructural development of the country. Responsibility of an engineer in ensuring the safety of built environment.	CO1	1
1.2	Brief introduction to major disciplines of Civil Engineering like Transportation Engineering, Structural Engineering, Geo-technical Engineering, Water Resources Engineering and Environmental Engineering.	CO1	2
1.3	*Introduction to buildings:* Types of buildings, selection of site for buildings, components of a residential building and their functions.	CO2	2
1.4	*Building rules and regulations:* Relevance of NBC, KBR & CRZ norms (brief discussion only)	CO2	1
1.5	*Building area:* Plinth area, built up area, floor area, carpet area and floor area ratio for a building as per KBR.	CO2	1
2	**Module 2**		**Total: 7**
2.1	*Surveying:* Importance, objectives and principles.	CO3	1
2.2	Bricks: - Classification, properties of good bricks, and tests on bricks	CO2	1
2.3	Stones: - *Qualities* of good stones, types of stones and their uses. Cement: - Good qualities of cement, types of cement and their uses.	CO2	1
2.4	Sand: - Classification, qualities of good sand and sieve analysis (basics only). Timber: - Characteristics, properties and uses.	CO2	1
2.5	Cement concrete: - Constituent materials, properties and types, Steel: - Steel sections and steel reinforcements, types and uses.	CO2	1

2.6	Modern construction materials: - Architectural glass, ceramics, plastics, composite materials, thermal and acoustic insulating materials, decorative panels, waterproofing materials, modern uses of gypsum, pre-fabricated building components (brief discussion only)	CO2	2
3	**Module 3**		**Total: 7**
3.1	Foundations: - Bearing capacity of soil (definition only), functions of foundations, types – shallow and deep (brief discussion only). Brick masonry: - Header and stretcher bond, English bond & Flemish bond– elevation and plan (one & one and a half brick wall only). Random rubble masonry.	CO2	2
3.2	Roofs: Functions, types; roofing materials (brief discussion only) Floors: Functions, types; flooring materials (brief discussion only)	CO2	2
3.3	*Basic infrastructure services:* MEP, HVAC, Elevators, escalators and ramps (Civil Engineering aspects only) fire safety for buildings	CO4	2
3.4	*Green buildings:*- Materials, energy systems, water management and environment for green buildings. (brief discussion only)	CO5	1
4	**MODULE 4**		
4.1	Analysis of thermodynamic cycles: Carnot, Otto, and Diesel cycle-Derivation of efficiency of these cycles, Problems to calculate heat added, heat rejected, net work and efficiency	4	
4.2	IC Engines: CI, SI, 2-Stroke, 4-Stroke engines. Listing the parts of different types of IC Engines, efficiencies of IC Engines(Description only)	2	
4.3	Air, Fuel, cooling and lubricating systems in SI and CI Engines, CRDI, MPFI. Concept of hybrid engines	2	
5	**MODULE 5**		
5.1	Refrigeration: Unit of refrigeration, reversed Carnot cycle, COP, vapour compression cycle (only description and no problems)	1	
5.2	Definitions of dry, wet & dew point temperatures, specific humidity and relative humidity, Cooling and dehumidification, Layout of unit and central air conditioners.	1	

5.3	Description about working with sketches : Reciprocating pump, Centrifugal pump, Pelton turbine, Francis turbine and Kaplan turbine. Overall efficiency, Problems on calculation of input and output power of pumps and turbines (No velocity triangles)	4
5.4	Description about working with sketches of: Belt and Chain drives, Gear and Gear trains, Single plate clutches	3
6	**MODULE 6**	
6.1	Manufacturing Process: Basic description of the manufacturing processes – Sand Casting, Forging, Rolling, Extrusion and their applications.	2
6.2	Metal Joining Processes :List types of welding, Description with sketches of Arc Welding, Soldering and Brazing, and their applications	1
6.3	Basic Machining operations: Turning, Drilling, Milling and Grinding Description about working with block diagrams of: Lathe, Drilling machine, Milling machine, CNC Machine	3
6.4	Principle of CAD/CAM, Rapid and Additive manufacturing	1

HUN 102	PROFESSIONAL COMMUNICATION	CATEGORY	L	T	P	CREDIT
		MNC	2	0	2	--

Preamble: Clear, precise, and effective communication has become a *sine qua non* in today's information-driven world given its interdependencies and seamless connectivity. Any aspiring professional cannot but master the key elements of such communication. The objective of this course is to equip students with the necessary skills to listen, read, write, and speak so as to comprehend and successfully convey any idea, technical or otherwise, as well as give them the necessary polish to become persuasive communicators.

Prerequisite: None

Course Outcomes: After the completion of the course the student will be able to

CO 1	Develop vocabulary and language skills relevant to engineering as a profession
CO 2	Analyze, interpret and effectively summarize a variety of textual content
CO 3	Create effective technical presentations
CO 4	Discuss a given technical/non-technical topic in a group setting and arrive at generalizations/consensus
CO 5	Identify drawbacks in listening patterns and apply listening techniques for specific needs
CO 6	Create professional and technical documents that are clear and adhering to all the necessary conventions

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1										3		2
CO 2										1		3
CO 3						1			1	3		
CO 4										3		1
CO 5		1							2	3		
CO 6	1					1			1	3		

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	50	50	2 hours

Continuous Internal Evaluation

Total Marks: 50

Attendance	: 10 marks
Regular assessment	: 25 marks
Series test (one test only, should include verbal aptitude for placement and higher studies, this test will be conducted for 50 marks and reduced to 15)	: 15 marks

Regular assessment

Project report presentation and Technical presentation through PPT	: 7.5 marks
Listening Test	: 5 marks
Group discussion/mock job interview	: 7.5 marks
Resume submission	: 5 marks

End Semester Examination

Total Marks: 50, Time: 2 hrs.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. List down the ways in which gestures affect verbal communication.
2. Match the words and meanings

Ambiguous	promotion
Bona fide	referring to whole
Holistic	not clear
Exaltation	genuine

3. Expand the following Compound Nouns - a. Water supply. b. Object recognition. c. Steam turbine

Course Outcome 2 (CO2)

1. Read the passage below and prepare notes:

Mathematics, rightly viewed, possesses not only truth, but supreme beauty—a beauty cold and austere, like that of sculpture, without appeal to any part of our weaker nature, without the gorgeous trappings of painting or music, yet sublimely pure, and capable of a stern perfection such as only the greatest art can show. The true spirit of delight, the exaltation, the sense of being more than man, which is the touchstone of the highest excellence, is to be found in mathematics as surely as in poetry. What is best in mathematics deserves not merely to be learnt as a task, but to be assimilated as a part of daily thought, and brought again and again before the mind with ever-renewed encouragement. Real life is, to most men, a long second-best, a perpetual compromise between the ideal and the possible; but the world of pure reason knows no compromise, no practical limitations, no barrier to the creative activity embodying in splendid edifices the passionate aspiration after the perfect from which all great work springs. Remote from human passions, remote even from the pitiful facts of nature, the generations have gradually created an ordered cosmos, where pure thought can dwell as in its natural home, and where one, at least, of our nobler impulses can escape from the dreary exile of the actual world.

So little, however, have mathematicians aimed at beauty, that hardly anything in their work has had this conscious purpose. Much, owing to irrepressible instincts, which were better than avowed *beliefs, has been moulded by an unconscious taste; but much also has been spoilt by false notions of what was fitting. The characteristic excellence of mathematics is only to be found where the reasoning is rigidly logical: the rules of logic are to mathematics what those of structure are to architecture. In the most beautiful work, a chain of argument is presented in which every link is important on its own account, in which there is an air of ease and lucidity throughout, and the premises achieve more than would have been thought possible, by means which appear natural and inevitable. Literature embodies what is general in particular circumstances whose universal significance shines through their individual dress; but mathematics endeavours to present whatever is most general in its purity, without any irrelevant trappings.*

How should the teaching of mathematics be conducted so as to communicate to the learner as much as possible of this high ideal? Here experience must, in a great measure, be our guide; but some maxims may result from our consideration of the ultimate purpose to be achieved.

- From "On the teaching of mathematics" – Bertrand Russell

2. Enumerate the advantages and disadvantages of speed reading. Discuss how it can impact comprehension.

Course Outcome 3(CO3):

1. What are the key elements of a successful presentation?
2. Elucidate the importance of non-verbal communication in making a presentation
3. List out the key components in a technical presentation.

Course Outcome 4 (CO4):

1. Discuss: 'In today's world, being a good listener is more important than being a good Speaker.'
2. Listen to a video/live group discussion on a particular topic, and prepare a brief summary of the proceedings.
3. List the do's and don'ts in a group discussion.

Course Outcome 5 (CO5):

1. Watch a movie clip and write the subtitles for the dialogue.
2. What do you mean by barriers to effective listening? List ways to overcome each of these.
3. What are the different types of interviews? How are listening skills particularly important in Skype/telephonic interviews?

Course Outcome 6 (CO6):

1. Explain the basic structure of a technical report.
2. You have been offered an internship in a much sought-after aerospace company and are very excited about it. However, the dates clash with your series tests. Write a letter to the Manager – University Relations of the company asking them if they can change the dates to coincide with your vacation.
3. You work in a well-reputed aerospace company as Manager – University Relations. You are in charge of offering internships. A student has sent you a letter requesting you to change the dates allotted to him since he has series exams at that time. But there are no vacancies available during the period he has requested for. Compose an e-mail informing him of this and suggest that he try to arrange the matter with his college.

Syllabus

Module 1

Use of language in communication: Significance of technical communication Vocabulary Development: technical vocabulary, vocabulary used in formal letters/emails and reports, sequence words, misspelled words, compound words, finding suitable synonyms, paraphrasing, verbal analogies. Language Development: subject-verb agreement, personal passive voice, numerical adjectives, embedded sentences, clauses, conditionals, reported speech, active/passive voice.

Technology-based communication: Effective email messages, slide presentations, editing skills using software. Modern day research and study skills: search engines, repositories, forums such as Git Hub, Stack Exchange, OSS communities (MOOC, SWAYAM, NPTEL), and Quora; Plagiarism

Module 2

Reading, Comprehension, and Summarizing: Reading styles, speed, valuation, critical reading, reading and comprehending shorter and longer technical articles from journals, newspapers, identifying the various transitions in a text, SQ3R method, PQRST method, speed reading. Comprehension: techniques, understanding textbooks, marking and underlining, Note-taking: recognizing non-verbal cues.

Module 3

Oral Presentation: Voice modulation, tone, describing a process, Presentation Skills: Oral presentation and public speaking skills, business presentations, Preparation: organizing the material, self-Introduction, introducing the topic, answering questions, individual presentation practice, presenting visuals effectively.

Debate and Group Discussions: introduction to Group Discussion (GD), differences between GD and debate; participating GD, understanding GD, brainstorming the topic, questioning and clarifying, GD strategies, activities to improve GD skills

Module 4

Listening and Interview Skills Listening: Active and Passive listening, listening: for general content, to fill up information, intensive listening, for specific information, to answer, and to understand. Developing effective listening skills, barriers to effective listening, listening to longer technical talks, listening to classroom lectures, talks on engineering /technology, listening to documentaries and making notes, TED talks.

Interview Skills: types of interviews, successful interviews, interview etiquette, dress code, body language, telephone/online (skype) interviews, one-to-one interview & panel interview, FAQs related to job interviews

Module 5

Formal writing: Technical Writing: differences between technical and literary style. Letter Writing (formal, informal and semi formal), Job applications, Minute preparation, CV preparation (differences between Bio-Data, CV and Resume), and Reports. Elements of style, Common Errors in Writing: describing a process, use of sequence words, Statements of Purpose, Instructions, Checklists.

Analytical and issue-based Essays and Report Writing: basics of report writing; Referencing Style (IEEE Format), structure of a report; types of reports, references, bibliography.

Lab Activities

Written: Letter writing, CV writing, Attending a meeting and Minute Preparation, Vocabulary Building

Spoken: Phonetics, MMFS (Multimedia Feedback System), Mirroring, Elevator Pitch, telephone etiquette, qualities of a good presentation with emphasis on body language and use of visual aids.

Listening: Exercises based on audio materials like radio and podcasts. Listening to Song. practice and exercises.

Reading: Speed Reading, Reading with the help of Audio Visual Aids, Reading Comprehension Skills

Mock interview and Debate/Group Discussion: concepts, types, Do's and don'ts- intensive practice

Reference Books

1. English for Engineers and Technologists (Combined edition, Vol. 1 and 2), Orient Blackswan 2010.
2. Meenakshi Raman and Sangeetha Sharma,"Technical Communication: Principles and Practice", 2nd Edition, Oxford University Press, 2011
3. Stephen E. Lucas, "The Art of Public Speaking", 10th Edition; McGraw Hill Education, 2012.
4. Ashraf Rizvi, "Effective Technical Communication", 2nd Edition, McGraw Hill Education, 2017.
5. William Strunk Jr. & E.B. White, "The Elements of Style", 4th Edition, Pearson, 1999.
6. David F. Beer and David McMurrey, Guide to writing as an Engineer, John Willey. New York, 2004.
7. Goodheart-Willcox, "Professional Communication", First Edition , 2017.
8. Training in Interpersonal Skills: Tips for Managing People at Work, Pearson Education, India, 6 edition, 2015.
9. The Ace of Soft Skills: Attitude, Communication and Etiquette for Success, Pearson Education; 1 edition, 2013.
10. Anand Ganguly, "Success in Interview", RPH, 5th Edition, 2016.
11. Raman Sharma, "Technical Communications", Oxford Publication, London, 2004.

EST 102	PROGRAMING IN C	CATEGORY	L	T	P	CREDIT	YEAR OF INTRODUCTION
		ESC	2	1	2	4	2019

Preamble: The syllabus is prepared with the view of preparing the Engineering Graduates capable of writing readable C programs to solve computational problems that they may have to solve in their professional life. The course content is decided to cover the essential programming fundamentals which can be taught within the given slots in the curriculum. This course has got 2 Hours per week for practicing programming in C. A list showing 24 mandatory programming problems are given at the end. The instructor is supposed to give homework/assignments to write the listed programs in the rough record as and when the required theory part is covered in the class. The students are expected to come prepared with the required program written in the rough record for the lab classes.

Prerequisite: NIL

Course Outcomes: After the completion of the course the student will be able to

CO 1	Analyze a computational problem and develop an algorithm/flowchart to find its solution
CO 2	Develop readable* C programs with branching and looping statements, which uses Arithmetic, Logical, Relational or Bitwise operators.
CO 3	Write readable C programs with arrays, structure or union for storing the data to be processed
CO 4	Divide a given computational problem into a number of modules and develop a readable multi-function C program by using recursion if required, to find the solution to the computational problem
CO 5	Write readable C programs which use pointers for array processing and parameter passing
CO 6	Develop readable C programs with files for reading input and storing output

readable* - readability of a program means the following:

1. Logic used is easy to follow
2. Standards to be followed for indentation and formatting
3. Meaningful names are given to variables
4. Concise comments are provided wherever needed

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✔	✔	✔	✔		✔				✔	✔	✔
CO2	✔	✔	✔	✔	✔					✔		✔
CO3	✔	✔	✔	✔	✔					✔		✔
CO4	✔	✔	✔	✔	✔					✔	✔	✔
CO5	✔	✔			✔					✔		✔
CO6	✔	✔			✔					✔		✔

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination Marks
	Test 1 (Marks)	Test 2 (Marks)	
Remember	15	10	25
Understand	10	15	25
Apply	20	20	40
Analyse	5	5	10
Evaluate			
Create			

Mark distribution

Total Marks	CIE Marks	ESE Marks	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks

Continuous Assessment Test 1 (for theory, for 2 hrs) : 20 marks

Continuous Assessment Test 2 (for lab, internal examination, for 2 hrs) : 20 marks

Internal Examination Pattern: There will be two parts; Part A and Part B. Part A contains 5 questions with 2 questions from each module (2.5 modules x 2 = 5), having 3 marks for each question. Students should answer all questions. Part B also contains 5 questions with 2 questions from each module (2.5 modules x 2 = 5), of which a student should answer any one. The questions should not have sub-divisions and each one carries 7 marks.

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which a student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Sample Course Level Assessment Questions

Course Outcome 1 (CO1): Write an algorithm to check whether largest of 3 natural numbers is prime or not. Also, draw a flowchart for solving the same problem.

Course Outcome 2 (CO2): Write an easy to read C program to process a set of n natural numbers and to find the largest even number and smallest odd number from the given set of numbers. The program should not use division and modulus operators.

Course Outcome 3(CO3): Write an easy to read C program to process the marks obtained by n students of a class and prepare their rank list based on the sum of the marks obtained. There are 3 subjects for which examinations are conducted and the third subject is an elective where a student is allowed to take any one of the two courses offered.

Course Outcome 4 (CO4): Write an easy to read C program to find the value of a mathematical function f which is defined as follows. f(n) = n! / (sum of factors of n), if n is not prime and f(n) = n! / (sum of digits of n), if n is prime.

Course Outcome 5 (CO5): Write an easy to read C program to sort a set of n integers and to find the number of unique numbers and the number of repeated numbers in the given set of numbers. Use a function which takes an integer array of n elements, sorts the array using the Bubble Sorting Technique and returns the number of unique numbers and the number of repeated numbers in the given array.

Course Outcome 6 (CO6): Write an easy to read C program to process a text file and to print the Palindrome words into an output file.

Model Question paper

QP CODE: PAGES:3

Reg No:_______________

Name :_______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY FIRST SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR

***Course Code:* EST 102**

Course Name: Programming in C (Common to all programs)

Max.Marks:100 **Duration: 3 Hours**

PART A

Answer all Questions. Each question carries 3 Marks

1. Write short note on processor and memory in a computer.
2. What are the differences between compiled and interpreted languages? Give example for each.
3. Write a C program to read a Natural Number through keyboard and to display the reverse of the given number. For example, if "3214567" is given as input, the output to be shown is "7654123".
4. Is it advisable to use *goto* statements in a C program? Justify your answer.
5. Explain the different ways in which you can *declare & initialize* a single dimensional array.
6. Write a C program to read a sentence through keyboard and to display the count of white spaces in the given sentence.
7. What are the advantages of using functions in a program?
8. With a simple example program, explain *scope* and *life time* of variables in C.
9. Write a function in C which takes the address of a single dimensional array (containing a finite sequence of numbers) and the number of numbers stored in the array as arguments and stores the numbers in the same array in reverse order. Use pointers to access the elements of the array.
10. With an example, explain the different modes of opening a file. (10x3=30)

Part B

Answer any one Question from each module. Each question carries 14 Marks

11. (a) Draw a flow chart to find the position of an element in a given sequence, using linear searching technique. With an example explain how the flowchart finds the position of a given element. **(10)**

(b) Write a pseudo code representing the flowchart for linear searching. **(4)**

OR

12. (a) With the help of a flow chart, explain the bubble sort operation. Illustrate with an example. **(10)**

(b) Write an algorithm representing the flowchart for bubble sort. **(4)**

13. (a) Write a C program to read an English Alphabet through keyboard and display whether the given Alphabet is in upper case or lower case. **(6)**

(b) Explain how one can use the builtin function in C, *scanf*to read values of different data types. Also explain using examples how one can use the builtin function in C, *printf*for text formatting. **(8)**

OR

14. (a) With suitable examples, explain various operators in C. (10)

(b) Explain how characters are stored and processed in C. **(4)**

15. (a) Write a function in C which takes a 2-Dimensional array storing a matrix of numbers and the order of the matrix (number of rows and columns) as arguments and displays the sum of the elements stored in each row. **(6)**

(b) Write a C program to check whether a given matrix is a diagonal matrix. **(8)**

OR

16. (a) Without using any builtin string processing function like *strlen*, *strcat* etc., write a program to concatenate two strings. **(8)**

(b) Write a C program to perform bubble sort. **(6)**

17. (a) Write a function namely *myFact* in C to find the factorial of a given number. Also, write another function in C namely*nCr* which accepts two positive integer parameters *n* and *r* and returns the value of the mathematical function*C(n,r)*(n! / (r! x (n - r)!)). The function *nCr* is expected to make use of the factorial function *myFact.* *(10)*

(b) What is recursion? Give an example. **(4)**

OR

18. (a) With a suitable example, explain the differences between a structure and a union in C. **(6)**

(b) Declare a structure namely *Student* to store the details (*roll number, name, mark_for_C*) of a student. Then, write a program in C to find the average mark obtained by the students in a class for the subject *Programming in C* (using the field *mark_for_C*). Use array of structures to store the required data **(8)**

19. (a) With a suitable example, explain the concept of pass by reference. **(6)**

(b) With a suitable example, explain how pointers can help in changing the content of a single dimensionally array passed as an argument to a function in C. **(8)**

OR

20. (a) Differentiate between sequential files and random access files? **(4)**

(b) Using the prototypes explain the functionality provided by the following functions. (10)

rewind()

i. fseek()

ii. ftell()

iii. fread()

iv. *fwrite()* ***(14X5=70)***

SYLLABUS

Programming in C (Common to all disciplines)

Module 1

Basics of Computer Hardware and Software

Basics of Computer Architecture: processor, Memory, Input& Output devices

Application Software & System software: Compilers, interpreters, High level and low level languages

Introduction to structured approach to programming, Flow chart Algorithms, Pseudo code (*bubble sort, linear search - algorithms and pseudocode*)

Module 2

Program Basics

Basic structure of C program: Character set, Tokens, Identifiers in C, Variables and Data Types , Constants, Console IO Operations, printf and scanf

Operators and Expressions: Expressions and Arithmetic Operators, Relational and Logical Operators, Conditional operator, size of operator, Assignment operators and Bitwise Operators. Operators Precedence

Control Flow Statements: If Statement, Switch Statement, Unconditional Branching using goto statement, While Loop, Do While Loop, For Loop, Break and Continue statements.(Simple programs covering control flow)

Module 3

Arrays and strings

Arrays Declaration and Initialization, 1-Dimensional Array, 2-Dimensional Array

String processing: In built String handling functions (strlen, strcpy, strcat and strcmp, puts, gets)

Linear search program, bubble sort program, simple programs covering arrays and strings

Module 4

Working with functions

Introduction to modular programming, writing functions, formal parameters, actual parameters Pass by Value, Recursion, Arrays as Function Parameters structure, union, Storage Classes, Scope and life time of variables, *simple programs using functions*

Module 5

Pointers and Files

Basics of Pointer: declaring pointers, accessing data though pointers, NULL pointer,array access using pointers, pass by reference effect

File Operations: open, close, read, write, append

Sequential access and random access to files: In built file handlingfunctions (*rewind() ,fseek(), ftell(), feof(), fread(), fwrite()*), *simple programs covering pointers and files.*

Text Books

1. Schaum Series, Gottfried B.S.,Tata McGraw Hill,Programming with C
2. E. Balagurusamy, Mcgraw Hill,Programming in ANSI C
3. Asok N Kamthane, Pearson,Programming in C
4. Anita Goel, Pearson, Computer Fundamentals

Reference Books

1. Anita Goel and Ajay Mittal, Pearson, Computer fundamentals and Programming in C
2. Brian W. Kernighan and Dennis M. Ritchie, Pearson, C Programming Language
3. Rajaraman V, PHI, Computer Basics and Programming in C
4. Yashavant P, Kanetkar, BPB Publications, Let us C

Course Contents and Lecture Schedule

Module 1: Basics of Computer Hardware and Software		**(7 hours)**
1.1	**Basics of Computer Architecture:** Processor, Memory, Input& Output devices	**2 hours**
1.2	**Application Software & System software:** Compilers, interpreters, High level and low level languages	**2 hours**
1.3	Introduction to structured approach to programming, Flow chart	**1 hours**
1.4	Algorithms, Pseudo code (*bubble sort, linear search - algorithms and pseudocode*)	**2 hours**
Module 2: Program Basics		**(8 hours)**
2.1	**Basic structure of C program:** Character set, Tokens, Identifiers in C, Variables and Data Types , Constants, Console IO Operations, printf and scanf	**2 hours**
2.2	**Operators and Expressions:** Expressions and Arithmetic Operators, Relational and Logical Operators, Conditional operator, sizeof operator, Assignment operators and Bitwise Operators. Operators Precedence	**2 hours**

2.3	**Control Flow Statements:** If Statement, Switch Statement, Unconditional Branching using goto statement, While Loop, Do While Loop, For Loop, Break and Continue statements.*(Simple programs covering control flow)*	**4 hours**
Module 3: Arrays and strings:		**(6 hours)**
3.1	Arrays Declaration and Initialization, 1-Dimensional Array, 2-Dimensional Array	**2 hours**
3.2	**String processing:** In built String handling functions(*strlen, strcpy, strcat and strcmp, puts, gets*)	**2 hours**
3.3	Linear search program, bubble sort program, *simple programs covering arrays and strings*	**3 hours**
Module 4: Working with functions		**(7 hours)**
4.1	Introduction to modular programming, writing functions, formal parameters, actual parameters	**2 hours**
4.2	Pass by Value, Recursion, Arrays as Function Parameters	**2 hours**
4.3	structure, union, Storage Classes,Scope and life time of variables, *simple programs using functions*	**3 hours**
Module 5: Pointers and Files		**(7 hours)**
5.1	**Basics of Pointer**: declaring pointers, accessing data though pointers, NULL pointer,array access using pointers, pass by reference effect	**3 hours**
5.2	**File Operations**: open, close, read, write, append	1 **hours**
5.3	**Sequential access and random access to files:** In built file handlingfunctions (*rewind() ,fseek(), ftell(), feof(), fread(), fwrite()*)**,** *simple programs covering pointers and files.*	**2 hours**

C PROGRAMMING LAB (Practical part of EST 102, Programming in C)

Assessment Method: The Academic Assessment for the Programming lab should be done internally by the College. The assessment shall be made on 50 marks and the mark is divided as follows: Practical Records/Outputs - 20 marks (internal by the College), Regular Lab Viva - 5 marks (internal by the College), Final Practical Exam – 25 marks (internal by the College).

The mark obtained out of 50 will be converted into equivalent proportion out of 20 for CIE computation.

LIST OF LAB EXPERIMENTS

1. Familiarization of Hardware Components of a Computer

2. Familiarization of Linux environment – How to do Programming in C with Linux

3. Familiarization of console I/O and operators in C

i) Display "Hello World"

ii) Read two numbers, add them and display theirsum

iii) Read the radius of a circle, calculate its area and display it

iv)Evaluate the arithmetic expression ((a -b / c * d + e) * (f +g)) and display its solution.Read the values of the variables from the user through console.

4. Read 3 integer values and find the largest amoung them.

5. Read a Natural Number and check whether the number is prime or not

6. Read a Natural Number and check whether the number is Armstrong or not

7. Read n integers, store them in an array and find their sum and average

8. Read n integers, store them in an array and search for an element in the array using an algorithm for Linear Search

9. Read n integers, store them in an array and sort the elements in the array using Bubble Sort algorithm

10. Read a string (word), store it in an array and check whether it is a palindrome word or not.

11. Read two strings (each one ending with a $ symbol), store them in arrays and concatenate them without using library functions.

12. Read a string (ending with a $ symbol), store it in an array and count the number of vowels, consonants and spaces in it.

13. Read two input each representing the distances between two points in the Euclidean space, store these in structure variables and add the two distance values.

14. Using structure, read and print data of n employees (*Name, Employee Id and Salary*)

15. Declare a union containing 5 string variables (*Name, House Name, City Name, State and Pin code*) each with a length of C_SIZE (user defined constant). Then, read and display the address of a person using a variable of the union.

16. Find the factorial of a given Natural Number n usingrecursive and non recursive functions

17. **R**ead a string (word), store it in an array and obtain its reverse by using a user defined function.

18. Write a menu driven program for performing matrix addition, multiplication and finding the transpose. Use functions to (i) read a matrix, (ii) find the sum of two matrices, (iii) find the product of two matrices, (i) find the transpose of a matrix and (v) display a matrix.

19. Do the following using pointers

i) add two numbers

ii) swap two numbers using a user defined function

20. Input and Print the elements of an array using pointers

21. Compute sum of the elements stored in an array using pointers and user defined function.

22. Create a file and perform the following

iii) Write data to the file

iv) Read the data in a given file & display the file content on console

v) append new data and display on console

23. Open a text input file and count number of characters, words and lines in it; and store the results in an output file.

CYL 120	ENGINEERING CHEMISTRY LAB	CATEGORY	L	T	P	CREDIT
		BSC	0	0	2	1

Preamble: To impart scientific approach and to familiarize with the experiments in chemistry relevant for research projects in higher semesters

Prerequisite: Experiments in chemistry introduced at the plus two levels in schools

Course outcomes: After the completion of the course the students will be able to

CO 1	Understand and practice different techniques of quantitative chemical analysis to generate experimental skills and apply these skills to various analyses
CO 2	Develop skills relevant to synthesize organic polymers and acquire the practical skill to use TLC for the identification of drugs
CO 3	Develop the ability to understand and explain the use of modern spectroscopic techniques for analysing and interpreting the IR spectra and NMR spectra of some organic compounds
CO 4	Acquire the ability to understand, explain and use instrumental techniques for chemical analysis
CO 5	Learn to design and carry out scientific experiments as well as accurately record and analyze the results of such experiments
CO 6	Function as a member of a team, communicate effectively and engage in further learning. Also understand how chemistry addresses social, economical and environmental problems and why it is an integral part of curriculum

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3				2							3
CO 2	3				3							3
CO 3	3				3							3
CO 4	3				3							3
CO 5	3				1							3
CO 6	3				1							3

Mark distribution

Total Marks	CIE marks	ESE marks	ESE Duration(Internal)
100	100	-	1 hour

Continuous Internal Evaluation Pattern:

Attendance : 20 marks
Class work/ Assessment /Viva-voce : 50 marks
End semester examination (Internally by college) : 30 marks

End Semester Examination Pattern: Written Objective Examination of one hour

SYLLABUS

LIST OF EXPERIMENTS (MINIMUM 8 MANDATORY)

1. Estimation of total hardness of water-EDTA method
2. Potentiometric titration
3. Determination of cell constant and conductance of solutions.
4. Calibration of pH meter and determination of pH of a solution
5. Estimation of chloride in water
6. Identification of drugs using TLC
7. Determination of wavelength of absorption maximum and colorimetric estimation of Fe^{3+} in solution
8. Determination of molar absorptivity of a compound ($KMnO_4$ or any water soluble food colorant)
9. Synthesis of polymers (a) Urea-formaldehyde resin (b) Phenol-formaldehyde resin
10. Estimation of iron in iron ore
11. Estimation of copper in brass
12. Estimation of dissolved oxygen by Winkler's method
13. (a) Analysis of IR spectra (minimum 3 spectra) (b) Analysis of ^1H NMR spectra (minimum 3 spectra)
14. Flame photometric estimation of Na^+ to find out the salinity in sand
15. Determination of acid value of a vegetable oil
16. Determination of saponification of a vegetable oil

Reference Books

1. G. Svehla, B. Sivasankar, "Vogel's Qualitative Inorganic Analysis", Pearson, 2012.
2. R. K. Mohapatra, "Engineering Chemistry with Laboratory Experiments", PHI Learning, 2017.
3. Muhammed Arif, "Engineering Chemistry Lab Manual", Owl publishers, 2019.
4. Ahad J., "Engineering Chemistry Lab manual", Jai Publications, 2019.
5. Roy K Varghese, "Engineering Chemistry Laboratory Manual", Crownplus Publishers, 2019.
6. Soney C George, Rino Laly Jose, "Lab Manual of Engineering Chemistry", S. Chand & Company Pvt Ltd, New Delhi, 2019.

ESL 120	CIVIL & MECHANICAL WORKSHOP	CATEGORY	L	T	P	CREDIT	YEAR OF INTRODUCTION
			0	0	2	1	2019

Preamble: The course is designed to train the students to identify and manage the tools, materials and methods required to execute an engineering project. Students will be introduced to a team working environment where they develop the necessary skills for planning, preparing and executing an engineering project.

To enable the student to familiarize various tools, measuring devices, practices and different methods of manufacturing processes employed in industry for fabricating components.

Prerequisite: None

Course Outcomes: After the completion of the course the student will be able to:

Course Outcome	Course Outcome Description
CO 1	Name different devices and tools used for civil engineering measurements
CO 2	Explain the use of various tools and devices for various field measurements
CO 3	Demonstrate the steps involved in basic civil engineering activities like plot measurement, setting out operation, evaluating the natural profile of land, plumbing and undertaking simple construction work.
CO 4	Choose materials and methods required for basic civil engineering activities like field measurements, masonry work and plumbing.
CO 5	Compare different techniques and devices used in civil engineering measurements
CO 6	Identify Basic Mechanical workshop operations in accordance with the material and objects
CO 7	Apply appropriate Tools and Instruments with respect to the mechanical workshop trades
CO 8	Apply appropriate safety measures with respect to the mechanical workshop trades

Mapping of course outcomes with program outcomes:

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	1	-	-	-	1	1	-	-	2	2	-	-
CO 2	1	-	-	-	1	1	-	-	2	2	-	-
CO 3	1	-	-	-	1	1	-	2	2	2	1	-
CO 4	1	-	-	-	1	1	-	2	2	2	1	1
CO 5	1	-	-	-	1	1	-	-	2	2		1
CO 6	2											

CO 7	2											
CO 8	2											

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	70	30	1 hour

Assessment Procedure: Total marks allotted for the course is 100 marks. CIE shall be conducted for 70 marks and ESE for 30 marks. CIE should be done for the work done by the student and also viva voce based on the work done on each practical session. ESE shall be evaluated by written examination of one hour duration conducted internally by the institute.

Continuous Internal Evaluation Pattern:

Attendance : 20 marks
Class work/ Assessment /Viva-voce : 50 marks
End semester examination (Internally by college) : 30 marks

End Semester Examination Pattern: Written Objective Examination of one hour

SYLLABUS

PART 1

CIVIL WORKSHOP

Exercise 1. Calculate the area of a built-up space and a small parcel of land- Use standard measuring tape and digital distance measuring devices

Exercise 2. (a) Use screw gauge and vernier calliper to measure the diameter of a steel rod and thickness of a flat bar

(b) Transfer the level from one point to another using a water level

(c) Set out a one room building with a given plan and measuring tape

Exercise 3. Find the level difference between any two points using dumpy level

Exercise 4. (a) Construct a $1\frac{1}{2}$ thick brick wall of 50 cm height and 60 cm length using English bond. Use spirit level to assess the tilt of walls.

(b) Estimate the number of different types of building blocks to construct this wall.

Exercise 5. (a) Introduce the students to plumbing tools, different types of pipes, type of connections, traps, valves ,fixtures and sanitary fittings.

(b) Install a small rainwater harvesting installation in the campus

Reference Books:

1. Khanna P.N, “Indian Practical Civil Engineering Handbook”, Engineers Publishers.
2. Bhavikatti. S, "Surveying and Levelling (Volume 1)", I.K. International Publishing House
3. Arora S.P and Bindra S.P, " Building Construction", Dhanpat Rai Publications
4. S. C. Rangwala, “Engineering Materials,” Charotar Publishing House.

PART II

MECHANICAL WORKSHOP

LIST OF EXERCISES

(Minimum EIGHT units mandatory and FIVE models from Units 2 to 8 mandatory)

UNIT 1:- General : Introduction to workshop practice, Safety precautions, Shop floor ethics, Basic First Aid knowledge.

Study of mechanical tools, components and their applications: (a) Tools: screw drivers, spanners, Allen keys, cutting pliers etc and accessories (b) bearings, seals, O-rings, circlips, keys etc.

UNIT 2:- Carpentry : Understanding of carpentry tools

Minimum any one model

1. T –Lap joint 2. Cross lap joint 3. Dovetail joint 4. Mortise joints

UNIT 3:- Foundry : Understanding of foundry tools

Minimum any one model

1. Bench Molding 2. Floor Molding 3. Core making 4. Pattern making

UNIT 4: - Sheet Metal : Understanding of sheet metal working tools

Minimum any one model

1. Cylindrical shape
2. Conical shape
3. Prismatic shaped job from sheet metal

UNIT 5: - Fitting : Understanding of tools used for fitting

Minimum any one model

1. Square Joint
2. V- Joint
3. Male and female fitting

UNIT 6: - Plumbing : Understanding of plumbing tools, pipe joints

Any one exercise on joining of pipes making use of minimum three types of pipe joints

UNIT 7: - Smithy: Understanding of tools used for smithy.

Demonstrating the forge-ability of different materials (MS, Al, alloy steel and cast steels) in cold and hot states.

Observing the qualitative difference in the hardness of these materials

Minimum any one exercise on smithy

1. Square prism
2. Hexagonal headed bolt
3. Hexagonal prism
4. Octagonal prism

UNIT 8: -Welding: Understanding of welding equipments

Minimum any one welding practice

Making Joints using electric arc welding. bead formation in horizontal, vertical and over head positions

UNIT 9: - Assembly: Demonstration only

Dissembling and assembling of

1. Cylinder and piston assembly
2. Tail stock assembly
3. Bicycle
4. Pump or any other machine

UNIT 10: - Machines: Demonstration and applications of the following machines

Shaping and slotting machine; Milling machine; Grinding Machine; Lathe; Drilling Machine.

UNIT 11: - Modern manufacturing methods: Power tools, CNC machine tools, 3D printing, Glass cutting.

Course Contents and Lecture Schedule:

No	Topic	No of Sessions
1	**INTRODUCTION**	
1.1	Workshop practice, shop floor precautions, ethics and First Aid knowledge. Studies of mechanical tools, components and their applications: (a) Tools: screw drivers, spanners, Allen keys, cutting pliers etc and accessories (b) bearings, seals, O-rings, circlips, keys etc	1
2	**CARPENTRY**	
2.1	Understanding of carpentry tools and making minimum one model	2

3	**FOUNDRY**	
3.1	Understanding of foundry tools and making minimum one model	2
4	**SHEET METAL**	
4.1	Understanding of sheet metal working tools and making minimum one model	2
5	**FITTING**	
5.1	Understanding of fitting tools and making minimum one model	2
6	**PLUMBING**	
6.1	Understanding of pipe joints and plumbing tools and making minimum one model	2
7	**SMITHY**	
7.1	Understanding of smithy tools and making minimum one model	2
8	**WELDING**	
8.1	Understanding of welding equipments and making minimum one model	2
9	**ASSEMBLY**	
9.1	Demonstration of assembly and dissembling of multiple parts components	1
10	**MACHINES**	
10.1	Demonstration of various machines	1
11	**MODERN MANUFACTURING METHODS**	
11.1	Demonstrations of: power tools, CNC Machine tools, 3D printing, Glass cutting	1

SEMESTER -3

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
MET201	MECHANICS OF SOLIDS	PCC	3	1	0	4

Preamble:

This course helps the students to understand the concept of stress and strain in different types of structure/machine under various loading conditions. The course also covers simple and compound stresses due to forces, stresses and deflection in beams due to bending, torsion in circular section, strain energy, different theories of failure, stress in thin cylinder thick cylinder and spheres due to external and internal pressure.

Prerequisite: EST100 ENGINEERING MECHANICS

Course Outcomes:

After the completion of the course the student will be able to

CO 1	Determine the stresses, strains and displacements of structures by tensorial and graphical (Mohr's circle) approaches
CO 2	Analyse the strength of materials using stress-strain relationships for structural and thermal loading
CO 3	Perform basic design of shafts subjected to torsional loading and analyse beams subjected to bending moments
CO 4	Determine the deformation of structures subjected to various loading conditions using strain energy methods
CO 5	Analyse column buckling and appreciate the theories of failures and its relevance in engineering design

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3	2									1
CO 2	3	3	2									1
CO 3	3	3	1									2
CO 4	3	3	1									1
CO 5	3	3	1									1

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	20
Understand	20	20	30
Apply	20	20	50
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module and having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have a maximum of 2 subdivisions.

COURSE LEVEL ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. Determine the resultant traction at a point in a plane using the stress tensor.

2. Evaluate the principal stresses, principal strains and their directions from a given state of stress or strain.

3. Write the stress tensor and strain tensor.

Course Outcome 2 (CO2)

1. Write the generalized Hooke's law for stress-strain relations.

2. Estimate the state of strain from a given state of stress.

3. Analyse the strength of a structure subjected to thermal loading.

Course Outcome 3(CO3):

1. Design a shaft to transmit power and torque.

2. Draw the shear force and bending moment diagrams.

3. Determine the bending stress on a beam subjected to pure bending.

Course Outcome 4 (CO4):

1. Apply strain energy method to estimate the deformation of a structure.

2. Use strain energy method to calculate deformations for multiple loads.

3. Use strain energy method to estimate the loads acting on a structure for a maximum deflection.

Course Outcome 5 (CO5):

1. Analyse a column for buckling load.

2. Use Rankine formula to determine the crippling load of columns.

3. A bolt is subjected to a direct tensile load of 20 kN and a shear load of 15 kN. Suggest suitable size of this bolt according to various theories of elastic failure, if the yield stress in simple tension is 360 MPa. A factor of safety 2 should be used. Assume Poisson's ratio as 0.3.

SYLLABUS

Module 1

Deformation behaviour of elastic solids in equilibrium under the action of a system of forces, method of sections. Stress vectors on Cartesian coordinate planes passing through a point, stress at a point in the form of a matrix. Equality of cross shear, Cauchy's equation. Displacement, gradient of displacement, Cartesian strain matrix, strain- displacement relations (small-strain only), Simple problems to find strain matrix.Stress tensor and strain tensor for plane stress and plane strain conditions. Principal planes and principal stress,meaning of stress invariants, maximum shear stress. Mohr’s circle for 2D case.

Module 2

Stress-strain diagram, Stress–Strain curves of Ductile and Brittle Materials, Poisson’s ratio.
Constitutive equations-generalized Hooke’s law, equations for linear elastic isotropic solids in terms of Young’s Modulus and Poisson’s ratio, Hooke’s law for Plane stress and plane strain conditions
Relations between elastic constants E, G, ν and K(derivation not required).
Calculation of stress, strain and change in length in axially loaded members with single and composite materials, Effects of thermal loading – thermal stress and thermal strain. Thermal stress on a prismatic bar held between fixed supports.

Module 3

Torsional deformation of circular shafts, assumptions for shafts subjected to torsion within elastic deformation range, derivation of torsion formula Torsional rigidity, Polar moment of inertia, basic design of transmission shafts. Simple problems to estimate the stress in solid and hollow shafts.
Shear force and bending moment diagrams for cantilever and simply supported beams. Differential equations between load, shear force and bending moment.
Normal and shear stress in beams: Derivation of flexural formula, section modulus, flexural rigidity, numerical problems to evaluate bending stress, economic sections.
Shear stress formula for beams: (Derivation not required), shear stress distribution for a rectangular section.

Module 4

Deflection of beams using Macauley’s method
Elastic strain energy and Complementary strain energy. Elastic strain energy for axial loading, transverse shear, bending and torsional loads. Expressions for strain energy in terms of load, geometry and material properties of the body for axial, shearing, bending and torsional loads. Castigliano’s second theorem, reciprocal relation(Proof not required for Castigliano’s second theorem, reciprocal relation).
Simple problems to find the deflections using Castigliano’s theorem.

Module 5

Fundamentals of bucking and stability, critical load, equilibrium diagram for buckling of an idealized structure. Buckling of columns with pinned ends, Euler’s buckling theory for long columns. Critical stress, slenderness ratio, Rankine’s formula for short columns.
Introduction to Theories of Failure, Rankine’s theory for maximum normal stress, Guest’s theory for maximum shear stress, Saint-Venant’s theory for maximum normal strain, Hencky-von Mises theory for maximum distortion energy, Haigh’s theory for maximum strain energy

Text Books

1. Mechanics of materials in S.I. Units, R .C. Hibbeler, Pearson Higher Education 2018

2. Advanced Mechanics of Solids, L. S. Srinath, McGraw Hill Education

3. Design of Machine Elements, V. B Bhandari, McGraw Hill Education

Reference Books

1. Engineering Mechanics of Solids, Popov E., PHI 2002

2. Mechanics of Materials S. I. units, Beer, Johnston, Dewolf, McGraw Hills 2017

3. Mechanics of Materials, Pytel A. and Kiusalaas J. Cengage Learning India Private Limited, 2^{nd}Edition, 2015

4. Strength of Materials, Rattan, McGraw Hills 2011

5. Strength of Materials, Surendra Singh, S. K. Kataria& Sons

COURSE PLAN

No	Topic	No of lectures
1	**Module 1: Stress and Strain Analysis**	**9 hours**
1.1	Describe the deformation behaviour of elastic solids in equilibrium under the action of a system of forces. Describe method of sections to illustrate stress as resisting force per unit area. Stress vectors on Cartesian coordinate planes passing through a point and writing stress at a point in the form of a matrix.	2 hr
1.2	Equality of cross shear (Derivation not required). Write Cauchy's equation (Derivation not required),Find resultant stress, Normal and shear stress on a plane given stress tensor and direction cosines (no questions for finding direction cosines).	2 hr
1.3	Displacement, gradient of displacement, Cartesian strain matrix, Write strain-displacement relations (small-strain only), Simple problems to find strain matrix given displacement field (2D and 3D), write stress tensor and strain tensor for Plane stress and plane strain conditions.	1 hr
1.4	Concepts of principal planes and principal stress, characteristic equation of stress matrix and evaluation of principal stresses and principal planes as an eigen value problem, meaning of stress invariants, maximum shear stress	2 hrs
1.5	Mohr's circle for 2D case: find principal stress, planes, stress on an arbitrary plane, maximum shear stress graphically using Mohr's circle	2 hrs
2	**Module 2: Stress - Strain Relationships**	**9 hours**
2.1	Stress-strain diagram, Stress–Strain curves of Ductile and Brittle Materials, Poisson's ratio	1 hr
2.2	Constitutive equations-generalized Hooke's law, equations for linear elastic isotropic solids in in terms of Young's Modulus and Poisson's ratio (3D). Hooke's law for Plane stress and plane strain conditions Relations between elastic constants E, G, ν and K(derivation not required), Numerical problems	2 hrs
2.3	Calculation of stress, strain and change in length in axially loaded members with single and composite materials, Effects of thermal loading – thermal stress and thermal strain. Thermal stress on a prismatic bar held between fixed supports.	2 hrs
2.4	Numerical problems for axially loaded members	4 hrs
3	**Module 3: Torsion of circular shafts, Shear Force-Bending Moment Diagrams and Pure bending**	**9 hours**
3.1	Torsional deformation of circular shafts, assumptions for shafts subjected to torsion within elastic deformation range, derivation of torsion formula	1 hr
3.2	Torsional rigidity, Polar moment of inertia, comparison of solid and hollow shaft. Simple problems to estimate the stress in solid and hollow shafts	1 hr
3.3	Numerical problems for basic design of circular shafts subjected to externally applied torques	1 hr
3.4	Shear force and bending moment diagrams for cantilever and simply	2 hrs

	supported beams subjected to point load, moment, UDL and linearly varying load	
3.5	Differential equations between load, shear force and bending moment.	1 hr
3.6	Normal and shear stress in beams: Derivation of flexural formula, section modulus, flexural rigidity, numerical problems to evaluate bending stress, economic sections Shear stress formula for beams: (Derivation not required),numerical problem to find shear stress distribution for rectangular section	3 hrs
4	**Module 4: Deflection of beams, Strain energy**	**8 hours**
4.1	Deflection of cantilever and simply supported beams subjected to point load, moment and UDL using Macauley's method (procedure and problems with multiple loads)	2 hrs
4.2	Linear elastic loading, elastic strain energy and Complementary strain energy. Elastic strain energy for axial loading, transverse shear, bending and torsional loads (short derivations in terms of loads and deflections).	2 hr
4.3	Expressions for strain energy in terms of load, geometry and material properties of the body for axial, shearing, bending and torsional loads. Simple problems to solve elastic deformations	2 hrs
4.4	Castigliano's second theorem to find displacements, reciprocal relation, (Proof not required for Castigliano's second theorem and reciprocal relation).	1 hr
4.5	Simple problems to find the deflections using Castigliano's theorem	1 hr
5	**Module 5: Buckling of Columns, Theories of Failure**	**8 hours**
5.1	Fundamentals of bucking and stability, critical load, Euler's formula for long columns, assumptions and limitations, effect of end conditions(derivation only for pinned ends), equivalent length	2 hr
5.2	Critical stress, slenderness ratio, Rankine's formula for short columns, Problems	3 hr
5.3	Introduction to Theories of Failure. Rankine's theory for maximum normal stress, Guest's theory for maximum shear stress, Saint-Venant's theory for maximum normal strain	2 hr
5.4	Hencky-von Mises theory for maximum distortion energy, Haigh's theory for maximum strain energy	1 hr

MODEL QUESTION PAPER

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

THIRD SEMESTER B.TECH DEGREE EXAMINATION

Course Code : MET201

Course Name : MECHANICS OF SOLIDS

Max. Marks : 100 Duration : 3 Hours

PART – A

(*ANSWER ALL QUESTIONS, EACH QUESTION CARRIES 3 MARKS*)

1. Express the stress invariants in terms of Cartesian components of stress and principal stress.
2. Write down the Cauchy's strain displacement relationships.
3. Distinguish between the states of plane stress and plane strain.
4. Explain the generalized Hooke's law for a Linear elastic isotropic material.
5. List any three important assumptions in the theory of torsion.
6. Write the significance of flexural rigidity and section modulus in the analysis of beams.
7. Discuss reciprocal relation for multiple loads on a structure.
8. Express the strain energy for a cantilever beam subjected to a transverse point load at free end.
9. Discuss Saint-Venant's theory of failure.
10. Explain the term 'critical load' with reference to the buckling of slender columns.

PART – B

(*ANSWER ONE FULL QUESTION FROM EACH MODULE*)

MODULE – 1

11. a) The state of stress at a point is given by σ_{xx} = 12.31 MPa, σ_{yy} = 8.96 MPa, σ_{zz} = 4.34 MPa, τ_{xy} = 4.2 MPa, τ_{yz} = 5.27 MPa, τ_{xz} = 0.84 MPa. Determine the principal stresses. (7 marks)

b) The displacement field for a body is given by **u**= $(x^2 + y)$***i***+ $(3 + z)$ ***j*** + $(x^2 + 2y)$***k***. What is the deformed position of a point originally at (3,1,–2)? Write the strain tensor at the point (−3,−1,2).

(7 marks)

OR

12. a) The state of plane stress at a point is given by σ_{xx} = 40 MPa, σ_{yy} = 20 MPa and τ_{xy} = 16 MPa. Using Mohr's circle determine the i) principal stresses and principal planes and ii) maximum shear stress. (7 marks)

b) The state of stress at a point is given below. Find the resultant stress vector acting on a plane with direction cosines n_x=0.47, n_y=0.82 and n_z=0.33. Find the normal and tangential stresses acting on this plane. (7 marks)

$$\sigma_{ij} = \begin{bmatrix} 10 & 5 & -10 \\ 5 & 20 & -15 \\ -10 & -15 & -10 \end{bmatrix} MPa$$

MODULE – 2

13. a) Calculate Modulus of Rigidity and Young's Modulus of a cylindrical bar of diameter 30 mm and of 1.5 m length if the longitudinal strain in a bar during a tensile stress is four times the lateral strain. Find the change in volume when the bar is subjected to a hydrostatic pressure of 100 N/mm^2. Take E = 10^5 N/mm (9 marks)

b) A straight bar 450 mm long is 40 mm in diameter for the first 250 mm length and 20 mm diameter for the remaining length. If the bar is subjected to an axial pull of 15 kNfind the maximum axial stress produced and the total extension of the bar. Take E = 2x10^5 N/mm^2 (5 marks)

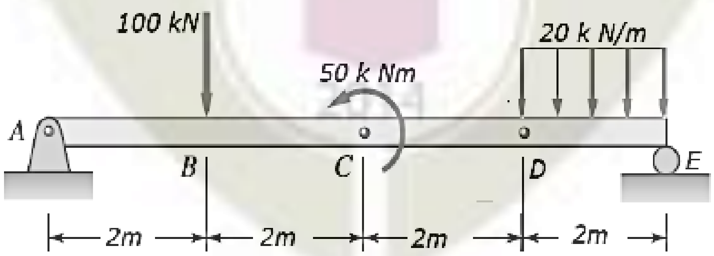
OR

14. a) A brass bar 20mm diameter is enclosed in a steel tube of 25mm internal diameter and 50mm external diameter. Both bar and tube is of same length and fastened rigidly at their ends. The composite bar is free of stress at 20°C. To what temperature the assembly must be heated to generate a compressive stress of 48MPa in brass bar? Also determine the stress in steel tube. E_{steel} = 200GPa and E_{brass} = 84GPa, $\alpha_{steel} = 12 \times 10^{-6}$ / °C and $\alpha_{brass} = 18 \times 10^{-6}$ / °C. (9 marks)

b) Draw the stress-strain diagram for a ductile material and explain the salient points. (5 marks)

MODULE – 3

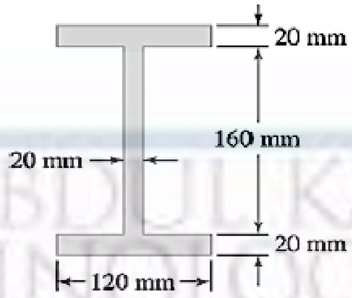
15. a) Draw shear force and bending moment diagram for the beam given in the figure. (9 marks)



b) Compare the strength of a hollow shaft of diameter ratio 0.75 to that of a solid shaft by considering the permissible shear stress. Both the shafts are of same material, of same length and weight. (5 marks)

OR

16. a) A simply supported beam of span of 10 m carries a UDL of 40 kN/m. The cross section is of I shape as given below. Calculatethe maximum stress produced due to bending and plot thebending stress distribution. (9 marks)



b) The shear stress of a solid shaft is not to exceed 40 N/mm^2 when the power transmitted is 20 kW at 200 rpm. Determine the minimum diameter of the shaft. (5 marks)

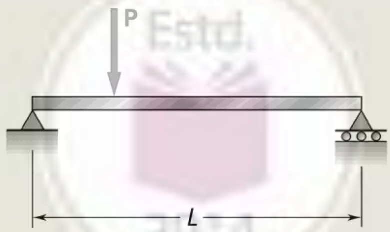
MODULE – 4

17. a) A horizontal girder of steel having uniform section is 14 m long and is simply supported at its ends. It carries concentrated loads of 120 kN and 80 kN at two points 3 m and 4.5 m from the two ends respectively. Moment of inertia for the section of the girder is 16×10^8 mm^4 and E_s = 210 kN/mm^2. Calculate the deflection of the girder at points under the two loads and maximum deflection using Macaulay's method. (8 marks)

b) Derive the expressions for elastic strain energy in terms of applied load/moment and material property for the cases of a) Axial force b) Bending moment. (6 marks)

OR

18. a) Calculate the displacement in the direction of load P applied at a distance of L/3 from the left end for a simply supported beam of span L as shown in the figure.



(10 marks)

b) State Castigliano's second theorem and explain its significance. (4 marks)

MODULE – 5

19. a) Find the crippling load for a hollow steel column 50mm internal diameter and 5mm thick. The column is 5m long with one end fixed and other end hinged. Use Rankine's formula and Rankine's constant as 1/7500 and σ_c = 335 N/mm^2. Compare this load by crippling load given by Euler's formula. Take E = 110 GPa. (8 marks)

b) Explain the maximum normal stress theory, maximum strain energy theory and maximum shear stress theory of failure. (6 marks)

OR

20. a) The principal stresses at a point in an elastic material are 22 N/mm^2(tensile), 110 N/mm^2 (tensile) and 55 N/mm^2 (compressive). If the elastic limit in simple tension is 210 N/mm^2, then determine whether the failure of material will occur or not according to Maximum principal stress theory, Maximum shear stress theory and maximum distortion energy theory. (9 marks)

b) Derive Euler's formula for a column with both ends hinged. (5 marks)

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
MET203	MECHANICS OF FLUIDS	PCC	3	1	-	4

Preamble :

This course provides an introduction to the properties and behaviour of fluids. It enables to apply the concepts in engineering, pipe networks. It introduces the concepts of boundary layers, dimensional analysis and model testing

Prerequisite : NIL

Course Outcomes :

After completion of the course the student will be able to

CO1	Define Properties of Fluids and Solve hydrostatic problems
CO2	Explain fluid kinematics and Classify fluid flows
CO3	Interpret Euler and Navier-Stokes equations and Solve problems using Bernoulli's equation
CO4	Evaluate energy loses in pipes and sketch energy gradient lines
CO5	Explain the concept of boundary layer and its applications
CO6	Use dimensional Analysis for model studies

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2										
CO2	3	2	1									
CO3	3	2	1									
CO4	3	3	2									
CO5	3	2	1									
CO6	3	2	1									

Assessment Pattern

Blooms Category	CA			ESA
	Assignment	Test - 1	Test - 2	
Remember	25	20	20	10
Understand	25	40	40	20
Apply	25	40	40	70
Analyse	25			
Evaluate				
Create				

Continuous Internal Evaluation Pattern:

Attendance : 10 marks

Continuous Assessment Test (2 numbers) : 25 marks

Assignment/Quiz/Course project : 15 marks

Mark distribution & Duration of Examination :

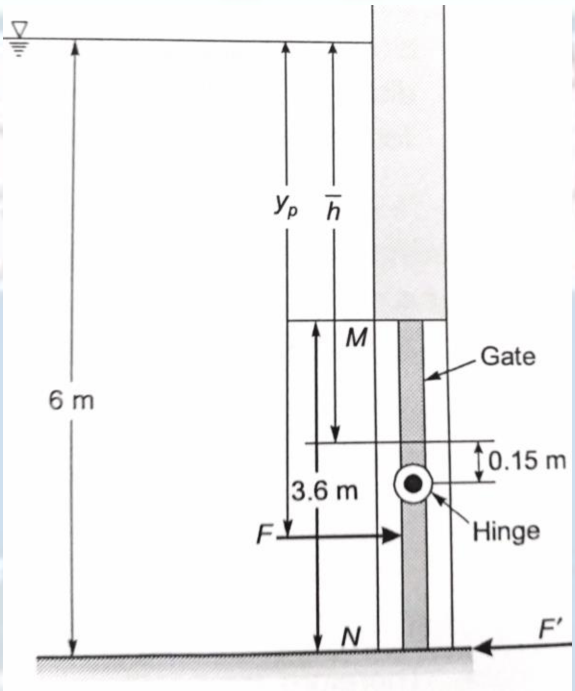
Total Marks	CA	ESE	ESE Duration
150	50	100	3 Hours

End semester pattern:

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Outcome 1

1. A 3.6 × 1.5 m wide rectangular gate MN is vertical and is hinged at point 0.15 m below the center of gravity of the gate. The total depth of water is 6 m. What horizontal force must be applied at the bottom of the gate to keep the gate closed.



2. A stationary liquid is stratified so that its density is $\rho_0(1 + h)$ at a depth h below the free surface. At a depth h in this liquid, what is the pressure in excess of $\rho_0 gh$?

3. If the velocity profile of a fluid is parabolic with free stream velocity 120 cm/s occurring at 20 cm from the plate, calculate the velocity gradients and shear stress at a distance of 0, 10, 20 cm from the plate. Take the viscosity of fluid as 8.5 poise.

Course Outcome 2

1. Differentiate between the Eulerian and Lagrangian method of representing fluid motion.

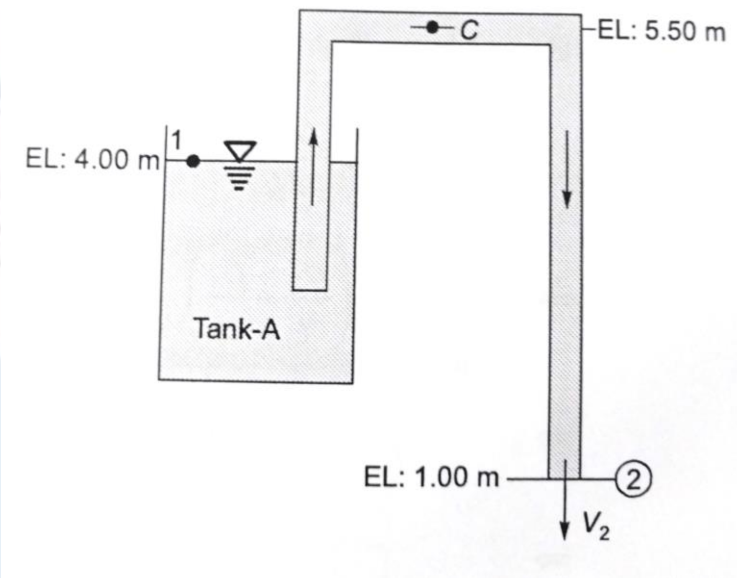
2. A velocity field is given by $u = 3y^2$, $v = 2x$ and $w = 0$ in arbitrary units. Is this flow steady or unsteady? Is it two or three dimensional? At (x,y,z)=(2,1,0), compute

   (a) velocity
   (b) local acceleration
   (c) convective acceleration

3. A stream function in two dimensional flow is $\psi = 2xy$. Show that the flow is irrotational and determine the corresponding velocity potential φ.

Course Outcome 3

1. A siphon consisting of a pipe of 15 cm diameter is used to empty kerosene oil (relative density=0.8) from tank A. The siphon discharges to the atmosphere at an elevation of 1.00 m. The oil surface in the tank is at an elevation of 4.00 m. The center line of the siphon pipe at its highest point C is at an elevation of 5.50 m. Estimate,



   (a) Discharge in the pipe
   (b) Pressure at point C.

   The losses in the pipe can be assumed to be 0.5 m up to the summit and 1.2 m from summit to the outlet.

2. Derive the Euler's equation of motion along a streamline and from that derive the Bernouli's equation.

3. What is water hammer? Explain different cases of water hammer. Derive the expression for pressure rise in any one of the case.

Course Outcome 4

1. Two reservoir with a difference in water surface elevation of 10 m are connected by a pipeline AB and BC joined in series. Pipe AB is 10 cm in diameter, 20 m long and has a value of friction factor $f = 0.02$. Pipe BC is 16 cm diameter, 25 m long and has a friction factor f=0.018. The junctions with reservoirs and between pipes are abrupt.

   (a) Sketch Total energy line and Hydraulic gradient line
   (b) Calculate the discharge.

2. Oil of viscosity 0.1 Pas and specific gravity 0.9 flows through a horizontal pipe of 25 mm diameter. If the pressure drop per meter length of the pipe is 12 KPa, determine

   (a) Discharge through the pipe
   (b) Shear stress at the pipe wall
   (c) Reynolds number of the flow

(d) Power required in Watts if the length of the pipe is 50m

3. In a hydraulic power plant, a reinforced concrete pipe of diameter D is used to transmit water from the reservoir to the turbine. If H is the total head supply at the entrance of the pipe and h_f is the loss of head in the pipe, then derive the condition for maximum power supply through the pipe.

Course Outcome 5

1. Write a short note on boundary layer separation and discuss any two methods to control the same.

2. Find the displacement thickness, momentum thickness and energy thickness for velocity distribution in boundary layer given by

$$\frac{u}{U_\infty} = 2\left(\frac{y}{\delta}\right) - \left(\frac{y}{\delta}\right)^2$$

3. A thin plate is moving in still atmospheric air at a velocity of 4m/s. The length of the plate is 0.5 m and width 0.4 m. Calculate the

   (a) thickness of the boundary layer at the end of the plate and

   (b) drag force on one side of the plate.

   Take density of air as 1.25 kg/m^3 and kinematic viscosity 0.15 stokes.

Course Outcome 6

1. State and explain Buckingham's pi theorem.

2. An underwater device is 1.5m long and is to move at 3.5 m/s speed. A geometrically similar model 30 cm long is tested in a variable pressure wind tunnel at a speed of 35 m/s. Calculate the pressure of air in the model if the model experience a drag force of 40 N, calculate the prototype drag force. [Assume density of water = 998 kg/m^3, density of air at standard atmospheric pressure = 1.17 kg/m^3, dynamic viscosity of air at local atmospheric pressure = $1.95 * 10^{-5}$ Pas and dynamic viscosity of water = $1 * 10^{-3}$ Pas]

3. Explain the importance of dimensionless numbers and discuss any two similarity laws. Where are these model laws used?

SYLLABUS

Module 1: Introduction: Fluids and continuum, Physical properties of fluids, density, specific weight, vapour pressure, Newton's law of viscosity. Ideal and real fluids, Newtonian and non-Newtonian fluids. Fluid Statics- Pressure-density-height relationship, manometers, pressure on plane and curved surfaces, center of pressure, buoyancy, stability of immersed and floating bodies, fluid masses subjected to uniform accelerations, measurement of pressure.

Module 2: Kinematics of fluid flow: Eulerian and Lagrangian approaches, classification of fluid flow, 1-D, 2-D and 3-D flow, steady, unsteady, uniform, non-uniform, laminar, turbulent, rotational, irrotational flows, stream lines, path lines, streak lines, stream tubes, velocity and acceleration in fluid, circulation and vorticity, stream function and potential function, Laplace equation, equipotential lines, flow nets, uses and limitations.

Module 3: Control volume analysis of mass, momentum and energy, Equations of fluid dynamics: Differential equations of mass, energy and momentum (Euler's equation), Navier-Stokes equations (without proof) in cartesian co-ordinates. Dynamics of Fluid flow: Bernoulli's equation, Energies in flowing fluid, head, pressure, dynamic, static and total head, Venturi and Orifice meters, Notches and Weirs (description only for notches and weirs). Hydraulic coefficients, Velocity measurements: Pitot tube and Pitot-static tube.

Module 4: Pipe Flow: Viscous flow: Reynolds experiment to classify laminar and turbulent flows, significance of Reynolds number, critical Reynolds number, shear stress and velocity distribution in a pipe, law of fluid friction, head loss due to friction, Hagen Poiseuille equation. Turbulent flow: Darcy-Weisbach equation, Chezy's equation Moody's chart, Major and minor energy losses, hydraulic gradient and total energy line, flow through long pipes, pipes in series, pipes in parallel, equivalent pipe, siphon, transmission of power through pipes, efficiency of transmission, Water hammer, Cavitation.

Module 5: Boundary Layer : Growth of boundary layer over a flat plate and definition of boundary layer thickness, displacement thickness, momentum thickness and energy thickness, laminar and turbulent boundary layers, laminar sub layer, velocity profile, Von- Karman momentum integral equations for the boundary layers, calculation of drag, separation of boundary and methods of control. Dimensional Analysis: Dimensional analysis, Buckingham's theorem, important non dimensional numbers and their significance, geometric, Kinematic and dynamic similarity, model studies. Froude, Reynolds, Weber, Cauchy and Mach laws- Applications and limitations of model testing, simple problems only

Text Books

John. M. Cimbala and Yunus A. Cengel, Fluid Mechanics: Fundamentals and Applications (4th edition, SIE), 2019

Robert W. Fox, Alan T. McDonald, Philip J. Pritchard and John W. Mitchell, Fluid Mechanics, Wiley India, 2018

Reference Books

White, F. M., Fluid Mechanics, McGraw Hill Education India Private Limited, 8th Edition, 2017

Rathakrishnan, E. Fluid Mechanics: An Introduction, Prentice Hall India, 3rd Edition 2012

COURSE PLAN

Module	Topics	Hours Allotted
I	Introduction: Fluids and continuum, Physical properties of fluids, density, specific weight, vapour pressure, Newton's law of viscosity. Ideal and real fluids, Newtonian and non-Newtonian fluids. Fluid Statics- Pressure-density-height relationship, manometers, pressure on plane and curved surfaces, center of pressure, buoyancy, stability of immersed and floating bodies, fluid masses subjected to uniform accelerations, measurement of pressure.	7-2-0
II	Kinematics of fluid flow: Eulerian and Lagrangian approaches, classification of fluid flow, 1-D, 2-D and 3-D flow, steady, unsteady, uniform, non-uniform, laminar, turbulent, rotational, irrotational flows, stream lines, path lines, streak lines, stream tubes, velocity and acceleration in fluid, circulation and vorticity, stream function and potential function, Laplace equation, equipotential lines, flow nets, uses and limitations.	6-2-0
III	Control volume analysis of mass, momentum and energy, Equations of fluid dynamics: Differential equations of mass, energy and momentum (Euler's equation), Navier-Stokes equations (without proof) in cartesian co-ordinates Dynamics of Fluid flow: Bernoulli's equation, Energies in flowing fluid, head, pressure, dynamic, static and total head, Venturi and Orifice meters, Notches and Weirs (description only for notches and weirs). Hydraulic coefficients, Velocity measurements: Pitot tube and Pitot-static tube.	6-2-0
IV	Pipe Flow: Viscous flow: Reynolds experiment to classify laminar and turbulent flows, significance of Reynolds number, critical Reynolds number, shear stress and velocity distribution in a pipe, law of fluid friction, head	9-3-0

	loss due to friction, Hagen Poiseuille equation. Turbulent flow: Darcy-Weisbach equation, Chezy's equation Moody's chart, Major and minor energy losses, hydraulic gradient and total energy line, flow through long pipes, pipes in series, pipes in parallel, equivalent pipe, siphon, transmission of power through pipes, efficiency of transmission, Water hammer, Cavitation.	
V	Boundary Layer : Growth of boundary layer over a flat plate and definition of boundary layer thickness, displacement thickness, momentum thickness and energy thickness, laminar and turbulent boundary layers, laminar sub layer, velocity profile, Von- Karman momentum integral equations for the boundary layers, calculation of drag, separation of boundary and methods of control. Dimensional Analysis: Dimensional analysis, Buckingham's theorem, important non dimensional numbers and their significance, geometric, Kinematic and dynamic similarity, model studies. Froude, Reynolds, Weber, Cauchy and Mach laws- Applications and limitations of model testing, simple problems only	8-2-0

MODEL QUESTION PAPER

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

IV SEMESTER B.TECH DEGREE EXAMINATION

MET203: MECHANICS OF FLUIDS

Mechanical Engineering

Maximum: 100 Marks | Duration: 3 hours

PART A

Answer all questions, each question carries 3 marks

1. The specific gravity of a liquid is 3.0. What are its specific weight, specific mass and specific volume.
2. State Pascal's law and give some examples where this principle is used.
3. Explain Streamlines, Streaklines and Pathlines.
4. What do you understand by the terms: (*i*) Total acceleration, (*ii*) Convective acceleration, and (*iii*) Local acceleration.
5. Name the different forces present in a fluid flow. For the Euler's equation of motion, which forces are taken into consideration.
6. Differentiate between pitot tube and pitot static tube.
7. Define and explain the terms (*i*) Hydraulic gradiant line and (*ii*) Total energy line.
8. Show that the coefficient of friction for viscous flow through a circular pipe is given by
$$f = \frac{16}{Re}$$
where Re is the Reynolds number.
9. What do you mean by repeating variables? How repeating variables are selected for dimensional analysis.
10. How will you determine whether a boundary layer flow is attached flow, detached flow or on the verge of separation.

(10×3=30 Marks)

PART B

Answer one full question from each module

MODULE-I

11. (a) Through a very narrow gap of height *h*, a thin plate of large extend is pulled at a velocity *V* . On one side of the plate is oil of viscosity μ_1 and on the other side oil of viscosity μ_2. Calculate the position of the plate so that

   i. the shear force on the two sides of the plate is equal.

   ii. the pull required to drag the plate is minimum.

   Assume linear velocity distribution in transverse direction. (7 Marks)

   (b) A metallic cube of 30 cm side and weight 500 N is lowered into a tank containing two fluid layers of water and mercury. Top edge of the cube is at water surface. Determine the position of the block at water mercury interface when it has reached equilibrium. (7 Marks)

12. (a) A rectangular tank 1.5 m wide, 3 m long and 1.8 m deep contains water to a depth of 1.2 m. Find the horizontal acceleration which may be imparted to the tank in the direction of length so that

   i. there is just no spilling from the tank

   ii. front bottom corner of the tank is just exposed.

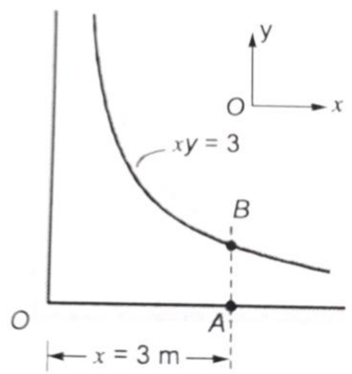
   (7 Marks)

   (b) A spherical water drop of 1 mm diameter splits up in air into 64 smaller drops of equal size. Find the work required in splitting up the drop. The surface tension coefficient of water in air = 0.073 *N/m* (7 Marks)

MODULE-II

13. (a) In a fluid flow field, velocity vector is given by $v = (0.5 + 8x)i + (0.5 - 0.8y)j$. Find the equation of streamline for the given velocity field. (7 Marks)

   (b) The stream function $\psi = 4xy$ in which ψ is in cm^2/s and x and y are in meters describe the incompressible flow between the boundary shown below:



   Calculate

   i. Velocity at B

   ii. Convective acceleration at B

iii. Flow per unit width across AB

(7 Marks)

14. (a) Consider the velocity field given by $u = x^2$ and $v = -2xy$. Find the circulation around the area bounded by $A(1, 1)$, $B(2, 1)$, $C(2, 2)$, $D(1, 2)$. (7 Marks)

(b) Verify whether the following are valid potential functions.

i. $\varphi = 2x + 5y$

ii. $\varphi = 4x^2 - 5y^2$

(7 Marks)

MODULE-III

15. (a) A submarine moves horizontally in sea and has its axis 15 m below the surface of the water. A pitot tube properly placed just in front of the submarine and along its axis is connected to two limbs of a U tube containing mercury. The difference of level is found to be 170 mm. Find the speed of the submarine knowing that the specific gravity of mercury is 13.6 and that of sea water is 1.026 with respect to water. (7 Marks)

(b) A pitot tube is inserted in a pipe of 30 cm diameter. The static pressure of the tube is 10 cm of mercury vacuum. The stagnation pressure at the centre of the pipe recorded by the pitot tube is 1.0 N/cm^2. Calculate the rate of flow of water through the pipe, if the mean velocity of flow is 0.85 times central velocity. Assume coefficient of tube as 0.98. (7 Marks)

16. (a) A smooth pipe of uniform diameter 25 cm, a pressure of 50 KPa was observed at section 1 which has an elevation of 10 m. At another section 2, at an elevation of 12 m, the pressure was 20 KPa and the velocity was 1.25 m/s. Determine the direction of flow and the head loss between the two sections. The fluid in the pipe is water. (8 Marks)

(b) Petrol of specific gravity 0.8 is following through a pipe of 30 cm diameter. The pipe is inclined at 30° to horizontal. The venturi has a throat diameter of 10 cm. U tube manometer reads 6.25 cm Hg. Calculate the discharge through the pipe. Assume $C_d = 0.98$. (6 Marks)

MODULE-IV

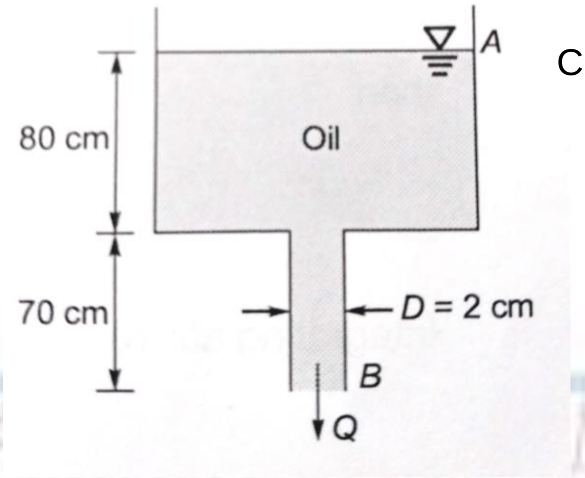
17. (a) Assuming viscous flow through a circular pipe derive the expression for,

i. Velocity distribution

ii. Shear stress distribution

Also plot the velocity and shear stress distribution. (7 Marks)

(b) A large tank shown in the figure has a vertical pipe 70 cm long and 2 cm in diameter. The tank contain oil of density 920 Kg/m^3 and viscosity 1.5 poise. Find the discharge through the tube when the height of oil level of the tank is 0.80 m above the pipe inlet.



(7 Marks)

18. (a) A compound piping system consist of 1800 m of 50 cm, 1200 m of 40 cm and 600 m of 30 com diameter pipes off same material connected in series.

   i. What is the equivalent length of a 40 cm pipe of same material?
   ii. What is the equivalent diameter of a pipe 3600 m long?
   iii. If three pipes are in parallel what is equivalent length of 50 cm pipe?

(10 Marks)

(b) A pipe line of 2100 m is used for transmitting 103 KW. The pressure at the inlet of the pipe is 392.4 N/cm^2. If the efficiency of transmission is 80%, find the diameter of the pipe. Take f = 0.005. (4 Marks)

MODULE-V

19. (a) The velocity profile u of a boundary layer flow over a flat plate is given by

$$\frac{u}{U_\infty} = \frac{3}{2}\left(\frac{y}{\delta}\right) - \frac{1}{2}\left(\frac{y}{\delta}\right)^3$$

If the boundary thickness is given as

$$\delta = \sqrt{\frac{280\nu x}{13U_\infty}}$$

develop the expression for local drag coefficient C_{fx} over the distance $x = L$ from the leading edge of the plate. (7 Marks)

(b) A model test is to be conducted in a water tunnel using a 1:20 model of a submarine which is used to travel at a speed of 12 *km/h* deep under the sea. The water temperature in the tunnel is so maintained that its kinematic viscosity is half as that of the sea water. At what speed the model test is to be conducted. (7 Marks)

20. (a) With a neat sketch explain the different regions of the boundary layer along a long thin flat plate. (7 Marks)

(b) Using Buckingham's pi theorem show that the velocity through a circular orifice is given by

$$V = \sqrt{2gH}\,\varphi\left(\frac{D}{H}, \frac{\mu}{\rho V H}\right)$$

where H is the head causing flow, D is the diameter of the orifice, μ is the coefficient of viscosity, ρ is the mass density and g is the acceleration due to gravity.(7 Marks)

MET 205	METALLURGY & MATERIAL SCIENCE	CATEGORY	L	T	P	Credits	Year of Introduction
		PCC	3	1	0	4	2019

Preamble:

Understanding of the correlation between the chemical bonds and crystal structure of metallic materials to their mechanical properties.

Recognize the importance of crystal imperfections including dislocations in plastic deformation.

Learning about different phases and heat treatment methods to tailor the properties of Fe-C alloys.

Examine the mechanisms of materials failure through fatigue and creep.

To determine properties of unknown materials and develop an awareness to apply this knowledge in material design

Prerequisite: PHT 110 Engineering Physics and CYT 100 Engineering Chemistry

Course Outcomes - At the end of the course students will be able to

CO 1	Understand the basic chemical bonds, crystal structures (BCC, FCC, and HCP), and their relationship with the properties.
CO 2	Analyze the microstructure of metallic materials using phase diagrams and modify the microstructure and properties using different heat treatments.
CO 3	How to quantify mechanical integrity and failure in materials.
CO 4	Apply the basic principles of ferrous and non-ferrous metallurgy for selecting materials for specific applications.
CO 5	Define and differentiate engineering materials on the basis of structure and properties for engineering applications.

Mapping of course outcomes with program outcomes (Minimum requirements)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	-	-	-	-	-	-	-	-		-	-
CO 2	-	3		-	-	-	-	-	-	-	-	-
CO 3		-	-	2	-	-	-	-	-	-	-	-
CO 4		-	-	-	3	-	-	-	-	-	-	-
CO 5	-	-	-	-		-	-	-	-	-	-	2

ASSESSMENT PATTERN

Bloom's taxonomy	Continuous Assessment Tests		End Semester Examination (Marks)
	Test 1 (Marks)	Test 11 (Marks)	
Remember	25	25	25
Understand	15	15	15
Apply	30	25	30
Analyze	10	10	10
Evaluate	10	15	10
Create	10	10	10

Mark distribution

Total Marks	CIE marks	ESE marks	ESE duration
150	50	100	3 Hours

Continuous Internal Evaluation (CIE) Pattern:

Attendance	10 marks
Regular class work/tutorials/assignments	15 marks
Continuous Assessment Test (Minimum 2 numbers)	25 marks

End semester pattern:- There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

COURSE LEVEL ASSESSMENT QUESTIONS

Part -A

Course Outcome 1 (CO1): Understand the basic chemical bonds, crystal structures (BCC, FCC, and HCP), and their relationship with the properties.

1. What are the attributes of atomic and crystalline structures into the stress - strain curve?
2. Explain the significance of long range and short range order of atomic arrangement on mechanical strength.
3. What is the difference between an allotrope and a polymorphism?
4. Draw the (112) and (111) planes in simple cubic cell.

Course Outcome 2 (CO2): Analyze the microstructure of metallic materials using phase diagrams and modify the microstructure and properties using different heat treatments.

1. What is the driving force for recrystallisation and grain growth of metallic crystals?
2. What is the driving force for the formation of spheroidite.
3. What is tempered martensite?
4. Why 100 % pure metals are weak in strength?

Part -B

Course Outcome 3 (CO3): How to quantify mechanical integrity and failure in materials

1. A small hole is drilled through a steel plate ahead of a crack, whether it can stop the crack's progress until repairs can be made. Explain in detail and derive the equation for the principle.
2. Draw and explain S-N curves for ferrous and non-ferrous metals. Explain different methods to improve fatigue resistance.
3. Explain different stages of creep; Give an application of creep phenomenon. What is superplasticity?

Course Outcome 4 (CO4): Apply the basic principles of ferrous and non-ferrous metallurgy for selecting materials for specific applications.

1. What are the classification, compositions and applications of high speed steel? identify 18:4:1
2. Describe the composition, properties, and use of Bronze and Gun metal.
3. Explain the importance of all the non-ferrous alloys in automotive applications. Elaborate on the composition, properties and typical applications of any five non-ferrous alloys.

Course Outcome 5 (CO5): Define and differentiate engineering materials on the basis of structure and properties for engineering applications.

1. Carbon is allowed to diffuse through a steel plate 15 mm thick. The concentrations of carbon at the two faces are 0.65 and 0.30kgC/m^3Fe, which are maintained constant. If the pre-exponential and activation energy are $6.2\times10^{-7}m^2/s$ and 80,000 J/mol, respectively, compute the temperature at which the diffusion flux is 1.43×10^{-9} kg/m^2-s.
2. Explain the fundamental effects of alloying elements in steel on polymorphic transformation temperatures, grain growth, eutectoid point, retardation of the transformation rates, formation and stability of carbides.
3. Describe the kind of fracture which may occur as a result of a loose fitting key on a shaft.

SYLLABUS

MODULE - 1

Earlier and present development of atomic structure - Primary bonds: - characteristics of covalent, ionic and metallic bond - properties based on atomic bonding: - Secondary bonds: - classification, application. *(Brief review only).*

Crystallography: - SC, BCC, FCC, HCP structures, APF - theoretical density simple problems - Miller Indices: - crystal plane and direction - Modes of plastic deformation: - Slip and twinning -Schmid's law - Crystallization: Effects of grain size, Hall - Petch theory, simple problems.

MODULE - II

Classification of crystal imperfections - forest of dislocation, role of surface defects on crack initiation- Burgers vector –Frank Read source - Correlation of dislocation density with strength and nano concept - high and low angle grain boundaries– driving force for grain growth and applications - Polishing and etching - X – ray diffraction, simple problems –SEM and TEM - Diffusion in solids, fick’s laws, mechanisms, applications of diffusion in mechanical engineering, simple problems.

MODULE - III

Phase diagrams: - need of alloying - classification of alloys - Hume Rothery`s rule - equilibrium diagram of common types of binary systems: five types - Coring - lever rule and Gibb`s phase rule - Reactions- Detailed discussion on Iron-Carbon equilibrium diagram with microstructure and properties -Heat treatment: - TTT, CCT diagram, applications - Tempering- Hardenability, Jominy end quench test, applications- Surface hardening methods.

MODULE - IV

Strengthening mechanisms - cold and hot working - alloy steels: how alloying elements affecting properties of steel - nickel steels - chromium steels - high speed steels -cast irons - principal non ferrous alloys.

MODULE - V

Fatigue: - creep -DBTT - super plasticity - need, properties and applications of composites, super alloy, intermetallics, maraging steel, Titanium - Ceramics:- structures, applications.

Text Books

1. Callister William. D., Material Science and Engineering, John Wiley, 2014
2. Higgins R.A. - Engineering Metallurgy part - I – ELBS,1998

Reference

1. Avner H Sidney, Introduction to Physical Metallurgy, Tata McGraw Hill,2009
2. Anderson J.C. *et.al*., Material Science for Engineers, Chapman and Hall,1990
3. Clark and Varney, Physical metallurgy for Engineers, Van Nostrand,1964
4. Dieter George E, Mechanical Metallurgy, Tata McGraw Hill, 1976
5. Raghavan V, Material Science and Engineering, Prentice Hall,2004
6. Reed Hill E. Robert, Physical metallurgy principles, 4th edition, Cengage Learning,2009
7. Myers Marc and Krishna Kumar Chawla, Mechanical behavior of materials, Cambridge University press,2008
8. Van Vlack -Elements of Material Science - Addison Wesley,1989
9. https://nptel.ac.in/courses/113/106/113106032

MODEL QUESTION PAPER

METALLURGY & MATERIAL SCIENCE - MET 205

Max. Marks : 100 **Duration : 3 Hours**

Part – A

Answer all questions.

Answer all questions, each question carries 3 marks

1. What is a slip system? Describe the slip systems in FCC, BCC and HCP metals
2. NASA's *Parker Solar Probe* will be the first-ever mission to "touch" the Sun. The spacecraft, about the size of a small car, will travel directly into the Sun's atmosphere about 4 million miles from the earth surface. Postulate the coolant used in the parker solar probe with chemical bonds.
3. What is the driving force for grain growth during heat treatment
4. What are the roles of surface imperfections on crack initiation
5. Explain the difference between hardness and hardenability.
6. What is tempered martensite? Explain its structure with sketch.
7. Postulate, why cast irons are brittle?
8. How are properties of aluminum affected by the inclusion of (a) copper and (b) silicon as alloying elements?
9. What is the grain size preferred for creep applications? Why. Explain thermal fatigue?
10. Explain fracture toughness and its attributes into a screw jack?

PART -B

Answer one full question from each module.

MODULE – 1

11. **a.** Calculate the APF of SC, BCC and FCC (7 marks).

b. What is slip system and explain why FCC materials exhibit ductility and BCC and HCP exhibit brittle nature with details of slip systems (7 marks).

OR

12. Explain the effect of: (i) Grain size; (ii) Grain size distribution and (iii) Grain orientation (iv) Grain shape on strength and creep resistance with neat sketches. Attributes of Hall-Petch equation and grain boundaries (14 marks).

MODULE – 2

13. **a**. Describe step by step procedure for metallographic specimen preparation? Name different types etchants used for specific metals and methods to determine grain size (7 marks).

b. Carbon is allowed to diffuse through a steel plate 15 mm thick. The concentrations of carbon at the two faces are 0.65 and 0.30 kgC/m^{3}Fe, which are maintained constant. If the pre-exponential and activation energy are 6.2×10^{-7} m^2/s and 80,000 J/mol, respectively, compute the temperature at which the diffusion flux is 1.43×10^{-9} kg/m^2-s (7 marks).

OR

14. a**.** Explain the fundamental differences of SEM and TEM with neat sketches (7 marks).

b**.** A beam of X-rays wavelength 1.54Å is incident on a crystal at a glancing angle of $8^o35'$ when the first order Bragg's reflection occurs calculate the glancing angle for third order reflection (7 marks).

MODULE – 3

15. Postulate with neat sketches, why 100% pure metals are weaker? What are the primary functions of alloying? Explain the fundamental rules governing the alloying with neat sketches and how is it accomplished in substitution and interstitial solid solutions (14 marks).

OR

16. Draw the isothermal transformation diagram of eutectoid steel and then sketch and label (1) A time temperature path that will produce 100% pure coarse and fine pearlite (2) A time temperature path that will produce 50% martensite and 50% bainite (3) A time temperature path that will produce 100% martensite (4) A time temperature path that will produce 100% bainite (14 marks).

MODULE – 4

17. Explain the effect of, polymorphic transformation temperature, formation and stability of carbides, grain growth, displacement of the eutectoid point, retardation of the transformation rates, improvement of corrosion resistance on adding alloy elements to steel (14 marks).

OR

18. Give the composition, microstructure, properties and applications of (i) Gray iron and SG iron. (ii) White iron and Gray iron. (iii) Malleable iron and Gray iron. (iv) Gray iron and Mottled iron, (v) SG iron and Vermicullar Graphite Iron (14 marks).

MODULE – 5

19. a A small hole is drilled through a steel plate ahead of a crack, whether it can stop the crack's progress until repairs can be made or not? Explain in detail and derive the equation (7 marks).

b What is ductile to brittle transition in steel DBTT? What are the factors affecting ductile to brittle transition? Narrate with neat sketch (7 marks).

OR

20. Classify ceramics with radius ratio with neat sketches. Explain with an example for each of the AX, AmXp, AmBmXp type structures in ceramics with neat sketch (14 marks).

COURSE CONTENT AND LECTURE SCHEDULES.

Module	TOPIC	No. of hours	Course outcomes
1.1	Earlier and present development of atomic structure; attributes of ionization energy and conductivity, electronegativity; correlation of atomic radius to strength; electron configurations; - Primary bonds: - characteristics of covalent, ionic and metallic bond: attributes of bond energy, cohesive force, density, directional and non-directional - properties based on atomic bonding:- attributes of deeper energy well and shallow energy well to melting temperature, coefficient of thermal expansion - attributes of modulus of elasticity in metal cutting process -Secondary bonds:- classification- hydrogen bond and anomalous behavior of ice float on water, application- specific heat, applications. (Brief review only).	2	CO1
1.2	Crystallography:- Crystal, space lattice, unit cell- SC, BCC, FCC, atomic packing factor and HCP structures - short and long range order - effects of crystalline and amorphous structure on mechanical properties.	2	CO1 CO2
1.3	Coordination number and radius ratio; theoretical density; simple problems - Polymorphism and allotropy.	1	
1.4	Miller Indices: - crystal plane and direction - Attributes of miller indices for slip system, brittleness of BCC, HCP and ductility of FCC - Modes of plastic deformation: - Slip and twinning.	1	CO5
1.5	Schmid's law, equation, critical resolved shear stress, correlation of slip system with plastic deformation in metals and applications.	1	
1.6	Mechanism of crystallization: Homogeneous and heterogeneous nuclei formation, under cooling, dendritic growth, grain boundary irregularity - Effects of grain size, grain size distribution, grain shape, grain orientation on dislocation/strength and creep resistance - Hall - Petch theory, simple problems.	2	CO2
2.1	Classification of crystal imperfections: - types of point and dislocations.	1	CO2
2.2	Effect of point defects on mechanical properties - forest of dislocation, role of surface defects on crack initiation - Burgers vector.	1	
2.3	Dislocation source, significance of Frank-Read source in metals deformation - Correlation of dislocation density with strength and nano concept, applications.	3	CO2
2.4	Significance high and low angle grain boundaries on dislocation – driving force for grain growth and applications during heat treatment.		
2.5	Polishing and etching to determine the microstructure and grain size- Fundamentals and crystal structure determination by X – ray diffraction, simple problems –SEM and TEM.	2	CO2 CO5
2.6	Diffusion in solids, fick’s laws, mechanisms, applications of diffusion in mechanical engineering, simple problems.	1	

3.1	Phase diagrams: - Limitations of pure metals and need of alloying - classification of alloys, solid solutions, Hume Rothery`s rule - equilibrium diagram of common types of binary systems: five types.	2	CO2 CO5
3.2	Coring - lever rule and Gibb`s phase rule - Reactions: - monotectic, eutectic, eutectoid, peritectic, peritectoid.	1	
3.3	Detailed discussion on Iron-Carbon equilibrium diagram with microstructure and properties changes in austenite, ledeburite, ferrite, cementite, special features of martensite transformation, bainite, spheroidite etc.	3	CO2 CO5
3.4	Heat treatment: - Definition and necessity – TTT for a eutectoid iron–carbon alloy, CCT diagram, applications - annealing, normalizing, hardening, spheroidizing.		
3.5	Tempering:- austermpering, martempering and ausforming - Comparative study on ductility and strength with structure of pearlite, bainite, spherodite, martensite, tempered martensite and ausforming.	1	CO2
3.6	Hardenability, Jominy end quench test, applications- Surface hardening methods:- no change in surface composition methods :- Flame, induction, laser and electron beam hardening processes- change in surface composition methods :carburizing and Nitriding; applications.	2	CO2
4.1	Cold working: Detailed discussion on strain hardening; recovery; re-crystallization, effect of stored energy; re- crystallization temperature - hot working, Bauschinger effect and attributes in metal forming.	1	
4.2	Alloy steels:- Effects of alloying elements on steel: dislocation movement, polymorphic transformation temperature, alpha and beta stabilizers, formation and stability of carbides, grain growth, displacement of the eutectoid point, retardation of the transformation rates, improvement in corrosion resistance, mechanical properties	1	CO4
4.3	Nickel steels, Chromium steels etc. – change of steel properties by adding alloying elements: - Molybdenum, Nickel, Chromium, Vanadium, Tungsten, Cobalt, Silicon, Copper and Lead - High speed steels - Cast irons: Classifications; grey, white, malleable and spheroidal graphite cast iron etc, composition, microstructure, properties and applications - Principal Non ferrous Alloys: - Aluminum, Copper, Magnesium, Nickel, study of composition, properties, applications, reference shall be made to the phase diagrams whenever necessary.(Topic 4.3 may be considered as a assignment).	4	CO4 CO5
4.4	Fatigue: - Stress cycles – Primary and secondary stress raisers - Characteristics of fatigue failure, fatigue tests, S-N curve.	1	CO3
4.5	Factors affecting fatigue strength: stress concentration, size effect, surface roughness, change in surface properties, surface residual stress - Ways to improve fatigue life – effect of temperature on fatigue, thermal fatigue and its applications in metal cutting.	2	

5.1	Fracture: – Brittle and ductile fracture – Griffith theory of brittle fracture – Stress concentration, stress raiser – Effect of plastic deformation on crack propagation - transgranular, intergranular fracture - Effect of impact loading on ductile material and its application in forging, applications - Mechanism of fatigue failure.	2	CO3
5.2	Structural features of fatigue: - crack initiation, growth, propagation - Fracture toughness (definition only), applications - Ductile to brittle transition temperature (DBTT) in steels and structural changes during DBTT, applications.	1	
5.3	Creep: - Creep curves – creep tests - Structural change:- deformation by slip, sub-grain formation, grain boundary sliding - Mechanism of creep deformation - threshold for creep, prevention against creep - Super plasticity: need and applications	2	CO3
5.4	Composites: - Need of development of composites; fiber phase; matrix phase; only need and characteristics of PMC, MMC, and CMC.	2	CO3 CO5
5.5	Modern engineering materials: - only fundamentals, need, properties and applications of, intermetallics, maraging steel, super alloys, Titanium-Ceramics:-coordination number and radius ratios- AX, A_mX_p, $A_mB_mX_p$ type structures – applications.	3	

MEL201	COMPUTER AIDED MACHINE DRAWING	CATEGORY	L	T	P	Credits	Year of Introduction
		PCC	0	0	3	2	2019

Preamble: To introduce students to the basics and standards of engineering drawing related to machines and components.

To make studentsfamiliarize with different types of riveted and welded joints, surface roughness symbols; limits, fits and tolerances.

To convey the principles and requirements of machine and production drawings.

To introduce the preparation ofdrawings of assembled and disassembled view of important valves and machine components used in mechanical engineering applications.

To introduce standard CAD packages for drafting andmodelingof engineering components.

Prerequisite: EST 110 - Engineering Graphics

Course Outcomes - At the end of the course students will be able to

CO1	Apply the knowledge of engineering drawings and standards to prepare standard dimensioned drawings of machine parts and other engineering components.
CO2	Preparestandard assembly drawings of machine components and valvesusing part drawings and bill of materials.
CO3	Apply limits and tolerances to components and choose appropriate fits for given assemblies
CO 4	Interpret the symbols of welded, machining and surface roughness on the component drawings.
CO 5	Prepare part and assembly drawings and Bill of Materials of machine components and valves using CAD software.

Mapping of course outcomes with program outcomes (Minimum requirements)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3									3		
CO2	3		2							3		
CO3	3	2										
CO4	3											
CO5	3				3					3		1

Assessment Pattern

Bloom's taxonomy	Continuous Assessment Tests	
	Test 1 PART A Sketching and Manual Drawing	Test 2 PART B CAD Drawing
Remember	25	20
Understand	15	15
Apply	30	20
Analyse	10	10
Evaluate	10	15
Create	10	20

Mark Distribution

Total Marks	CIE Marks	ESE marks	ESE duration
150	75	75	2.5 hours

Continuous Internal Evaluation (CIE) Pattern:

Attendance	15 marks
Regular class work/Drawing/Workshop Record/Lab Record and Class Performance	30 marks
Continuous Assessment Test (minimum two tests)	30 marks

End semester examination pattern

End semester examination shall be conducted on Sketching and CAD drawing on based complete syllabus

The following general guidelines should be maintained for the award of marks

Part A Sketching – 15 marks
Part B CAD drawing – 50marks
Viva Voce – 10 marks.

Conduct of University Practical Examinations

The Principals of the concerned Engineering Colleges with the help of the Chairmen/Chairperson will conduct the practical examination with the approval from the University and bonafide work / laboratory record, hall ticket, identity card issued by college are mandatory for appearing practical University examinations. No practical examination should be conducted without the presence of an external examiner appointed by the University.

END SEMSTER EXAMINATION

MODEL QUESTION PAPER

MEL 201: COMPUTER AIDED MACHINE DRAWING

Duration : 2.5 hours Marks : 75

Note :

1. All dimensions in mm
2. Assume missing dimensions appropriately
3. A4 size answer booklet shall be supplied
4. Viva Voce shall be conducted for 10 marks

PART A (SKETCHING)
(Answer any TWO questions). 15 marks

1. Sketch two views of a single riveted single strap butt joint. Take dimensions of the plate as 10mm. Mark the proportions in the drawing.

2. Show by means of neat sketches, any three methods employed for preventing nuts from getting loose on account of vibrations

3. Compute the limit dimensions of the shaft and the hole for a clearance fit based on shaft basis system if:

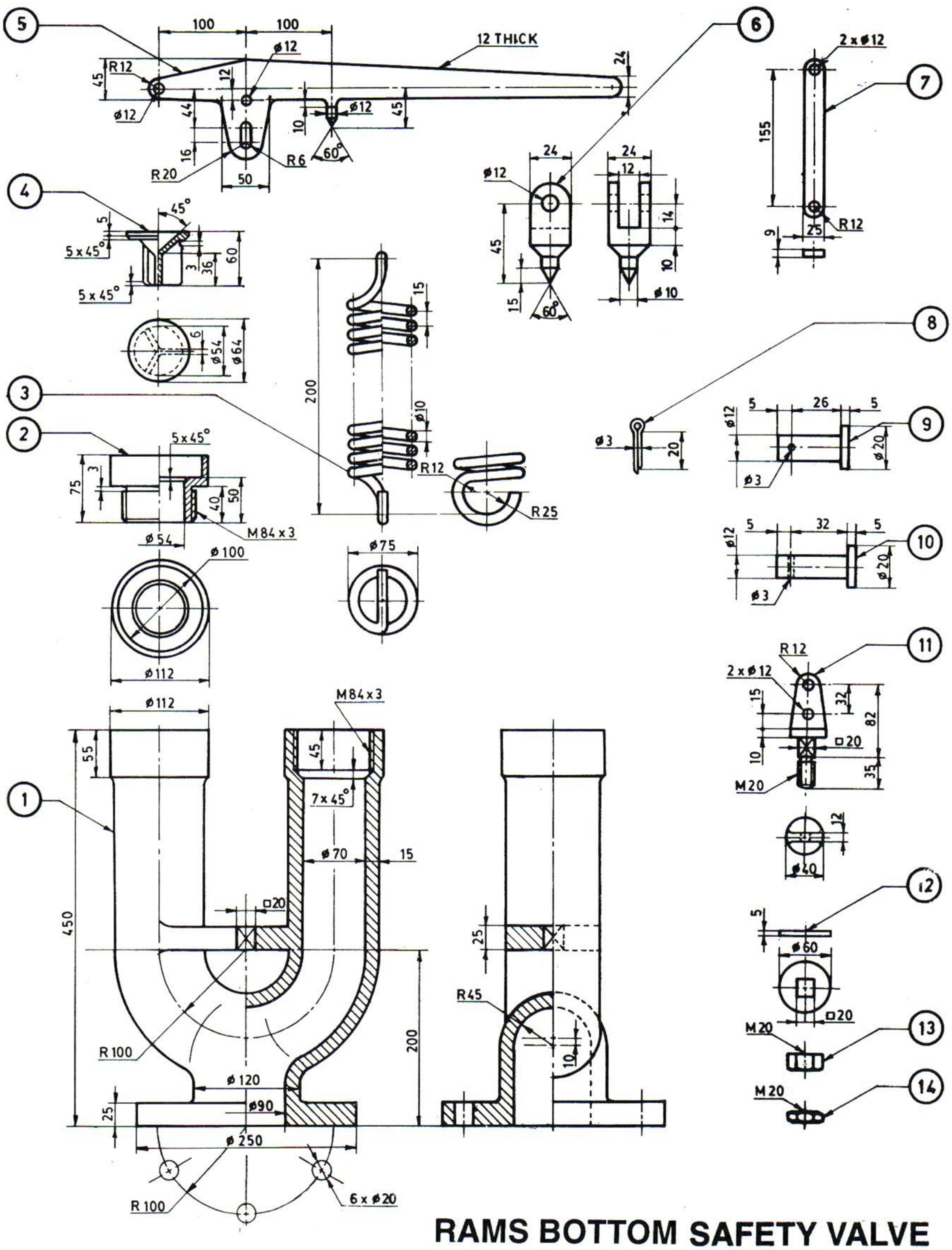
   Basic size= ϕ30 mm
   Minimum clearance = 0.007 mm
   Tolerance on hole = 0.021 mm
   Tolerance on shaft= 0.021 mm

   Check the calculated dimensions. Represent the limit dimensions schematically.

PART B (CAD DRAWING) 50 marks

4. Draw any two assembled views of the Rams Bottom Safety Valve as per the details given in the figure using any suitable CAD software. Also prepare bill of materials and tolerance data sheet.

Item	Description	Qty	Material	**Item**	Description	Qty	Material
1	Body	1	C.I.	**8**	Split Pin	3	M.S.
2	Valve Seat	2	G.M.	**9**	Pin for Link	2	M.S.
3	Spring	1	Steel	**10**	Pin for Pivot	1	M.S.
4	Valve	2	G.M.	**11**	Shackle	1	M.S.
5	Lever	1	M.S.	**12**	Washer	1	M.S.
6	Pivot	1	M.S.	**13**	Nut	1	M.S.
7	Link	2	M.S.	**14**	Lock Nut	1	M.S.



RAMS BOTTOM SAFETY VALVE

SYLLABUS

Introduction to machine drawing, drawing standards, fits, tolerances, surface roughness, assembly and part drawings of simple assemblies and subassemblies of machine parts viz., couplings, clutches, bearings, I.C. engine components, valves, machine tools, etc; introduction to CAD etc.

Text Books:

1. N. D. Bhatt and V.M. Panchal, Machine Drawing, Charotar Publishing House.
2. P I Varghese and K C John, Machine Drawing, VIP Publishers.

Reference Books

1. Ajeet Singh, Machine Drawing Includes AutoCAD, Tata McGraw-hill.
2. P S Gill, Machine Drawing, Kataria& Sons.

Course content and drawing schedules.

No:	List of Exercises	Course outcomes	No. of hours
	PART –A (Manual drawing) *(Minimum 6 drawings compulsory)*		
1	**Temporary Joint:** Principles of drawing, free hand sketching, Importance of machine Drawing. BIScode of practice for Engineering Drawing, lines, types of lines, dimensioning, scales of drawing, sectional views, **Riveted joints.**	CO 1	**3**
2	**Fasteners:** Sketching of conventional representation of welded joints,Bolts and Nuts **or** Keys and Foundation Bolts.	CO 1	**3**
3	**Fits and Tolerances:** Limits, Fits – Tolerances of individual dimensions – Specification of Fits – basic principles of geometric & dimensional tolerances. **Surface Roughness:** Preparation of production drawings and reading of part and assembly drawings, surface roughness, indication of surface roughness, etc.	CO 2	**3**
4	Detailed drawing of Cotter joints, Knuckle joint and Pipe joints	CO 2	**3**
5	**Assembly drawings(2D):** Stuffing box and Screw jack	CO 1 CO3 CO4	**3**

	PART –B **(CAD drawing)** *(Minimum 6 drawings compulsory)*		
6	Introduction to drafting software like Auto CAD, basic commands, keyboard shortcuts. Coordinate and unit setting, Drawing, Editing, Measuring, Dimensioning, Plotting Commands, Layering Concepts, Matching, Detailing, Detailed drawings.	CO 1 CO 2 CO 3 CO5	**3**
7	Drawing of Shaft couplings and Oldham's coupling	CO 1 CO 2 CO 3 CO5	**3**
8	**Assembly drawings(2D)with Bill of materials:** Lathe Tailstock and Universal joint	CO 1 CO3 CO5	**3**
9	**Assembly drawings(2D)with Bill of materials:** Connecting rod and Plummer block	CO 1 CO3 CO5	**3**
10	**Assembly drawings(2D)with Bill of materials:** Rams Bottom Safety Valve **OR** steam stop valve	CO 1 CO3 CO5	**3**

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
MEL203	MATERIALS TESTING LAB	PCC	0	0	3	2

Preamble:

The objective of this course is to give a broad understanding of common materials related to mechanical engineering with an emphasis on the fundamentals of structure-property-application and its relationships. A group of 6/7 students can conduct experiment effectively. A total of six experiments for the duration of 2 hours each is proposed for this course.

Prerequisite: A course on Engineering Mechanics is required

Course Outcomes:

After the completion of the course the student will be able to

CO 1	To understand the basic concepts of analysis of circular shafts subjected to torsion.
CO 2	To understand the behaviour of engineering component subjected to cyclic loading and failure concepts
CO 3	Evaluate the strength of ductile and brittle materials subjected to compressive, Tensile shear and bending forces
CO 4	Evaluate the microstructural morphology of ductile or brittle materials and its fracture modes (ductile /brittle fracture) during tension test
CO 5	To specify suitable material for applications in the field of design and manufacturing.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3				3							
CO 2	3	3	1		3				3	2	2	1
CO 3	3	3	3	1	3				3	2	3	2
CO 4	3	3	3	3	3	2	2	1	3	2	3	2
CO 5	3	3	3	1	3	2	2	1	3	2	3	2

Assessment Pattern

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	75	75	2.5 hours

Continuous Internal Evaluation Pattern:

Attendance	:	15 marks
Continuous Assessment	:	30 marks
Internal Test (Immediately before the second series test)	:	30 marks

End Semester Examination Pattern:

The following guidelines should be followed regarding award of marks

(a) Preliminary work	: 15 Marks
(b) Implementing the work/Conducting the experiment	: 10 Marks
(c) Performance, result and inference (usage of equipments and troubleshooting)	: 25 Marks
(d) Viva voce	: 20 marks
(e) Record	: 5 Marks

General instructions:

Practical examination to be conducted immediately after the second series test covering entire syllabus given below. Evaluation is a serious process that is to be conducted under the equal responsibility of both the internal and external examiners. The number of candidates evaluated per day should not exceed 20. Students shall be allowed for the University examination only on submitting the duly certified record. The external examiner shall endorse the record.

A minimum of 10 experiments are to be performed.

SYLLABUS

LIST OF EXPERIMENTS

1. To conduct tension test on ductile material (mild steel/ tor-steel/ high strength steel) using Universal tension testing machine and Extensometer.
2. To conduct compression test on ductile material (mild steel/ tor-steel/ high strength steel) using Universal tension testing machine and Extensometer.
3. To conduct tension test on Brittle material (cast iron) using Universal tension testing machine and Extensometer.
4. To conduct shear test on mild steel rod.
5. To conduct microstructure features of mild steel/copper/ brass/aluminium using optical microscope, double disc polishing machine, emery papers and etchent.
6. To conduct fractography study of ductile or brittle material using optical microscope.

7. To conduct Hardness test of a given material. (Brinell, Vickers and Rockwell)
8. To determine torsional rigidity of mild steel/copper/brass rod.
9. To determine flexural rigidity of mild steel/ copper/brass material using universal testing machine.
10. To determine fracture toughness of the given material using Universal tension testing machine.
11. To study the procedure for plotting S-N curve using Fatigue testing machine.
12. To conduct a Toughness test of the given material using Izod and Charpy Machine.
13. To determine spring stiffness of close coiled/open coiled/series/parallel arrangements.
14. To conduct bending test on wooden beam.
15. To conduct stress measurements using Photo elastic methods.
16. To conduct strain measurements using strain gauges.
17. To determine moment of inertia of rotating bodies.
18. To conduct an experiment to Verify Clerk Maxwell's law of reciprocal deflection and determine young's Modulus of steel.
19. To determine the surface roughness of a polished specimen using surface profilometer.

Reference Books

1. G E Dieter. Mechanical Metallurgy, McGraw Hill,2013

2. Dally J W, Railey W P, Experimental Stress analysis , McGarw Hill,1991

3. Baldev Raj, Jayakumar T, Thavasimuthu M., Practical Non destructive testing, Narosa Book

Distributors,2015

SEMESTER -3

MINOR

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
MET281	MECHANICS OF MATERIALS	VAC	3	1		4

Preamble:

This course helps the students to understand the concept of stress and strain, and practice the methodologies to analyze different types of structures under various loading conditions. The course also covers simple and compound stresses due to forces, stresses and deflection in beams due to bending, torsion of shafts.

Prerequisite: EST100 ENGINEERING MECHANICS

Course Outcomes:

After the completion of the course the student will be able to

CO 1	Discuss the concepts of stress and strain in deformable bodies due to structural and thermal loading
CO 2	Analyse the behaviour of materials under shear stress due to torsional loads acting in simple structural members
CO 3	Analyse beams using graphical and analytical methods to determine slope, deflection and stress
CO 4	Transform stresses and strains for plane stress problems mathematically and graphically and determine the principal stresses and its directions
CO 5	Analyze simple structures subjected to compound stresses, and columns subjected to buckling conditions

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3	2									1
CO 2	3	2	2									2
CO 3	3	3	2									1
CO 4	3	3	2									1
CO 5	3	2	2									1

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	20
Understand	20	20	50
Apply	20	20	30
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks

Continuous Assessment Test (2 numbers) : 25 marks

Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

COURSE LEVEL ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. Discuss normal strain and shear strain.

2. Determine the deformation of axially loaded bars.

3. State the principle of superposition.

Course Outcome 2 (CO2)

1. Compare the strength of a hollow shaft and a solid shaft.

2. List four important assumptions in the theory of torsion.

3. Determine the shear stress developed in a circular shaft subjected to torsional loading.

Course Outcome 3 (CO3):

1. Draw the Shear Force Diagram and Bending Moment Diagram of a beam.

2. Determine the bending stress and shear stresses in beams.

3. Explain pure bending with example.

Course Outcome 4 (CO4):

1. Estimate the deflection of the beam.

2. Discuss principal planes and principal stresses.

3. Determine principal stresses, maximum shear stress, plane of maximum shear stress and the resultant stress on the plane of maximum shear stress

Course Outcome 5 (CO5):

1. Draw the Mohr's circle.

2. Discuss the behaviour of structures under compound loading.

3. Calculate the safe buckling load.

MODEL QUESTION PAPER

THIRD SEMESTER MECHANICAL ENGINEERING

Time: 3 hrs **MET281 MECHANICS OF MATERIALS** **Max. Marks: 100**

PART – A

(*ANSWER ALL QUESTIONS, EACH QUESTION CARRIES 3 MARKS*)

1. Discuss the significance of Poisson's ratio.
2. Explain Hooke's law for linearly elastic isotropic material.
3. List the important assumptions in the theory of torsion.
4. Explain the term 'point of inflection'.
5. Define i) section modulus and ii) flexural rigidity
6. Explain how shear stress is distributed over the cross section of a rectangular beam.
7. Explain how double integration method can be used to obtain slope and deflection of beams.
8. Define principal stresses and principal planes and explain its significance
9. Draw the Mohr's circle for uniaxial tensile load acting on a mild steel bar.
10. Write a short note on Rankine's crippling load for a column.

PART – B

(*ANSWER ONE FULL QUESTION FROM EACH MODULE*)

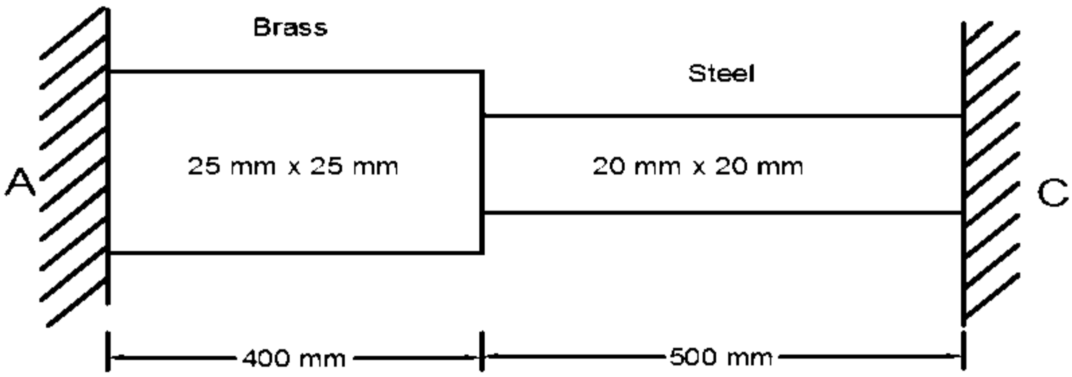
MODULE – 1

11. a) Draw a typical stress strain curve for mild steel under tension, describing briefly the salient points . (7 marks)

    b) A steel bar is fastened between two copper bars as shown in figure. The assembly is subjected to loads at positions as in figure. Calculate the total deformation of the bar and stresses at each section. E_{steel} = 200 GPa and E_{copper} = 110 GPa. (7 marks)

OR

12. a) A bar made of brass and steel as shown in figure is held between two rigid supports A and C. Find the stresses in each material if the temperature rises by 40°C. Take $E_b = 1 \times 10^5$ N/mm^2; $\alpha_b = 19 \times 10^{-6}$ / °C, $E_s = 2 \times 10^5$ N/mm^2 ; $\alpha_s = 12 \times 10^{-6}$ / °C. (9 marks)



b) A straight bar 450 mm long is 40 mm in diameter for the first 250 mm length and 20 mm diameter for the remaining length. If the bar is subjected to an axial pull of 15 kN, find the maximum and minimum stresses produced in it and the total extension of the bar. Take $E = 2 \times 10^5$ N/mm^2. (5 marks)

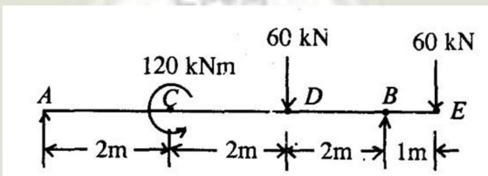
MODULE – 2

13. a) A solid aluminium shaft 1 m long and 50 mm diameter is to be replaced by a tubular steel shaft of the same length and the same outside diameter such that each of the two shafts could have the same angle of twist per unit torsional moment over the total length. What must the inner diameter of the tubular steel shaft be? Modulus of rigidity of the steel is three times that of aluminium. (10 marks)

b) A solid steel shaft transmits 20 kW at 120 rpm. Determine the smallest safe diameter of the shaft if the shear stress is not to exceed 40 MPa. (4 marks)

OR

14. a) Draw shear force and bending moment diagram for the beam given in the figure and mark all the salient points. (10 marks)

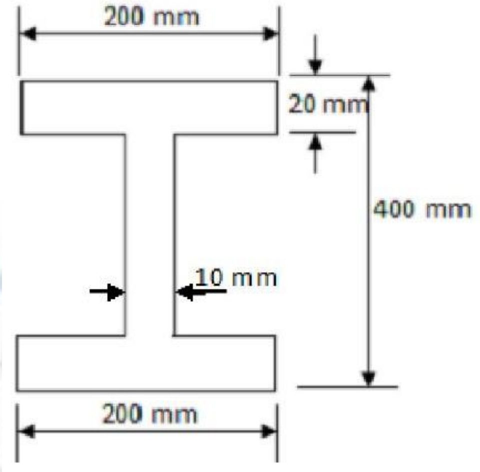


b) Explain the sign conventions used for shear forces and bending moments. (4 marks)

MODULE – 3

15. a) Derive the flexure formula for pure bending of a beam. State the assumptions (9 marks)

b) A rolled steel joist of I section has the dimensions as shown in figure. The beam carries a uniformly distributed load of 40 kN/mm^2 run on a span of 10 m, calculate the maximum stress produced due to bending. (5 marks)



OR

16. a) At the critical section of a beam of rectangular cross section with height 200 mm and width 100 mm, the value of the vertical shear force is 40 kN. Draw the shear stress distribution across the depth of the section. (9 marks)

    b) Derive the expression for shear stress in a beam. (5 marks)

MODULE – 4

17. a) A horizontal girder of steel having uniform section is 14 m long and is simply supported at its ends. It carries concentrated loads of 120 kN and 80 kN at two points 3 m and 4.5 m from the two ends respectively. Moment of inertia for the section of the girder is 16×10^8 mm^4 and E_s = 210 kN/mm^2. Calculate the deflection of the girder at points under the two loads and maximum deflection using Macaulay's method. (10 marks)

    b) A rectangular block of material is subjected to a tensile stress of 110 N/mm^2 on one plane and a tensile stress of 47 N/mm^2 on a plane at right angles, together with shear stresses of 63 N/mm^2 on the same planes. Find the magnitude of the principal stresses and maximum shear stress. (4 marks)

OR

18. a) Derive the transformation equations to determine normal and shear stress on an oblique plane. (10 marks)

    b) Define state of stress at point. Show the components of stress on a 3D rectangular element (4 marks)

MODULE – 5

19. a) At a point in a bracket the stresses on two mutually perpendicular planes are 120 N/mm^2 and 60 N/mm^2 both tensile. The shear stress across these planes is 30 N/mm^2. Find using the Mohr's stress circle i) Principal stresses at the point, ii) Maximum shear stress and iii) resultant stress on a plane inclined at 60° to the axis of the major principal stress. (10 marks)

b) Explain with the help of an example, how to calculate the normal stress when axial and transverse loads act simultaneously. (4 marks)

OR

20. a) Find the crippling load for a hollow steel column 50mm internal diameter and 5mm thick. The column is 5m long with one end fixed and other end hinged. Use Rankine's formula and Rankine's constant as 1/7500 and σ_c = 335 N/mm^2. (9 marks)

b) Derive Euler's formula for a column with both ends hinged. (5 marks)

SYLLABUS

Module 1

Introduction to analysis of deformable bodies – internal forces – method of sections – assumptions and limitations. Stress – stresses due to normal, shear and bearing loads – strength design of simple members. Definition of linear and shear strains.
Material behavior – uniaxial tension test – stress-strain diagrams – Hooke's law for linearly elastic isotropic material under axial and shear deformation, Poisson's ratio, Relationship between Young's modulus, Poisson's ratio and rigidity modulus(no derivations)
Deformation in axially loaded bars – thermal effects – statically indeterminate problems – principle of superposition.

Module 2

Torsion: Shafts - torsion theory of elastic circular bars – assumptions and limitations – polar modulus - torsional rigidity – economic cross-sections – statically indeterminate problems – shaft design for torsional load.
Beams- classification - diagrammatic conventions for supports and loading - axial force, shear force and bending moment in a beam.

Shear force and bending moment diagrams for simply supported, cantilever and overhanging beams (with concentrated loads, moment and uniformly distributed loads only), point of inflection and contraflexure

Module 3

Stresses in beams: Pure bending – flexure formula for beams assumptions and limitations – section modulus – flexural rigidity – economic sections, Problems to calculate bending stress for rectangular and I cross sections.

Shearing stress formula for beams – assumptions and limitations – Problems to calculate shear stress for beams of rectangular cross section.

Module 4

Deflection of beams: Moment-curvature relation – assumptions and limitations - double integration method – Macaulay's method.

Transformation of stress and strains: Definition of state of stress at a point (introduction to stress and strain tensors and its components only) -plane stress – plane strain - equations of transformation (2D) - principal planes and stresses - analogy between stress and strain transformation

Module 5

Mohr's circles of stress (2D)
Compound stresses: Combined axial, flexural and shear loads – combined bending and twisting loads.

Theory of columns: Buckling theory – Euler's formula for long columns – assumptions and limitations – effect of end conditions – slenderness ratio – Rankine's formula for intermediate columns.

Text Books

1. S.S Rattan, "Strength of Materials", McGraw Hill, 2nd edition, 2011.

Reference Books

1. Surya Patnaik, Dale Hopkins, Strength of Materials, Butterworth-Heinemann, 1st edition, 2003.
2. S. H. Crandal, N. C. Dhal, T. J. Lardner, An introduction to the Mechanics of Solids, McGraw Hill, 1999.
3. Mechanics of Materials, Pytel A. and Kiusalaas J. Cengage Learning India Private Limited, 2nd Edition, 2015
4. R. C. Hibbeler, Mechanics of Materials, Pearson Education, 2008.
5. I.H. Shames, J. H. Pitarresi, Introduction to Solid Mechanics, PHI, 2006.
6. James M. Gere, Mechanics of Materials, Brooks/Cole–Thomson Learning, 2004.
7. F. P. Beer, E. R. Johnston, J. T. DeWolf, Mechanics of Materials, Tata McGraw Hill, 2011.
8. MIT Open Courseware web course http://web.mit.edu/emech/dontindex-build/
9. Egor P. Popov, "Engineering Mechanics of Solids", PHI, 2nd edition, 2002.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures
1	**Module 1: Introduction to Stress and Strain Analysis**	**9**
1.1	Introduction to analysis of deformable bodies – internal forces – method of sections – assumptions and limitations.	1
1.2	Stress – stresses due to normal, shear and bearing loads – strength design of simple members. Definition of linear and shear strains.	2
1.3	Material behavior – uniaxial tension test – stress-strain diagrams for ductile and brittle materials under axial loading, significance of various points on the diagram	1
1.4	Hooke's law for linearly elastic isotropic material under axial and shear deformation, Poisson's ratio.	1
1.5	Relationship between Young's modulus, Poisson's ratio and rigidity modulus(no derivations)	1
1.6	Deformation in axially loaded bars – thermal effects – statically indeterminate problems – principle of superposition	3
2	**Module 2: Torsion and Introduction to beams**	**9**
2.1	Introduction to Torsion of Shafts – torsion theory of elastic circular bars – assumptions and limitations	1
2.2	Polar modulus - torsional rigidity – economic cross-sections – statically indeterminate problems	2
2.3	Shaft design for torsional load and numerical problems	1
2.4	Introduction to beam bending – sign conventions for supports, loads and moments, classifications of beams, demonstration of the behaviour of beams for various types of loads	2
2.5	Shear force and bending moment diagrams for simply supported, cantilever and overhanging beams (with concentrated loads, moment and uniformly distributed loads only), point of inflection and contraflexure (simple problems to draw the SF and BM diagrams)	3
3	**Module 3: Beam Bending**	**9**
3.1	Stresses in beams: Pure bending – flexure formula for beams assumptions, limitations and derivation	3
3.2	Section modulus – flexural rigidity – economic sections –, numerical problems to analyze the strength of beams (rectangular and I sections only)	3
3.3	Shearing stress in beams – assumptions and limitations – derivation of formula for shear stress, problems to calculate shear stress for beams of rectangular cross section	3
4	**Module 4: Deflection of Beams and Stress-Strain transformations**	**9**
4.1	Introduction to deflection of beams: Moment-curvature relation – assumptions and limitations	1

4.2	Double integration method – Macaulay's method – Simple problems to calculate deflection of cantilever and simply supported beams subjected to point load, moment and UDL	3
4.3	Definition of stress at a point (introduction to stress and strain tensors and its components only), plane stress, plane strain	2
4.4	Stress and strain transformations in 2D – transformation equations - analogy between stress and strain transformation	1
4.5	Determination of principal stresses and principal planes	2
5	**Module 5: Mohr's Circle, Compound Stress and Column Buckling**	**9**
5.1	Mohr's circles of stress (2D) – problems	2
5.2	Compound stresses: Combined axial, flexural and shear loads – discussion of practical situations of combined loading and compound stresses	2
5.3	Combined bending and twisting loads	1
5.4	Introduction to Buckling of columns – Buckling theory – Euler's formula for long columns – assumptions and limitations	2
5.5	Effect of end conditions – slenderness ratio – Rankine's formula for intermediate columns – numerical problems for maximum buckling	2

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
MET283	FLUID MECHANICS AND MACHINERY	VAC	3	1	0	4

Preamble:

This course provides an introduction to the properties and behaviour of fluids. It enables to apply the concepts in engineering. The course also gives an introduction of hydraulic pumps and turbines.

Prerequisite: NIL

Course Outcomes:

After the completion of the course the student will be able to

CO 1	Define Properties of Fluids and Solve hydrostatic problems
CO 2	Explain fluid kinematics and Classify fluid flows
CO 3	Interpret Euler's equation and Solve problems using Bernoulli's equation
CO 4	Explain the working of turbines and Select a turbine for specific application.
CO 5	Explain the characteristics of centrifugal and reciprocating pumps

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	2										
CO 2	3	2	1									
CO 3	3	2	1									
CO 4	3	2	1									
CO 5	3	2	1									

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	10
Understand	20	20	20
Apply	20	20	70
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

COURSE LEVEL ASSESSMENT QUESTIONS

Course Outcome 1

1. Define total pressure on a surface and center of pressure on a surface. What do you understand by the term hydrostatic pressure ?

2. An isosceles triangle of base 3m and altitude 6m is immersed vertically in water with its axis of symmetry horizontal. If the head on its axis is 9m, locate the center of pressure.

3. A triangular plate of 2m base and 2.5m altitude is immersed in water at an inclination of 30° with the base parallel to and at a depth of 2m from the free surface. Find the total hydrostatic force on the side of the plate and the position of its action.

Course Outcome 2

1. Define the following and give one practical example for each of the following:

   (a) laminar flow

   (b) Turbulent flow

   (c) Steady flow

   (d) Uniform flow

2. A two dimensional flow is described by the velocity components, $u = 5x^3$; $v = 15x^2y$. Evaluate the stream function, velocity, and acceleration at point P(1,2).

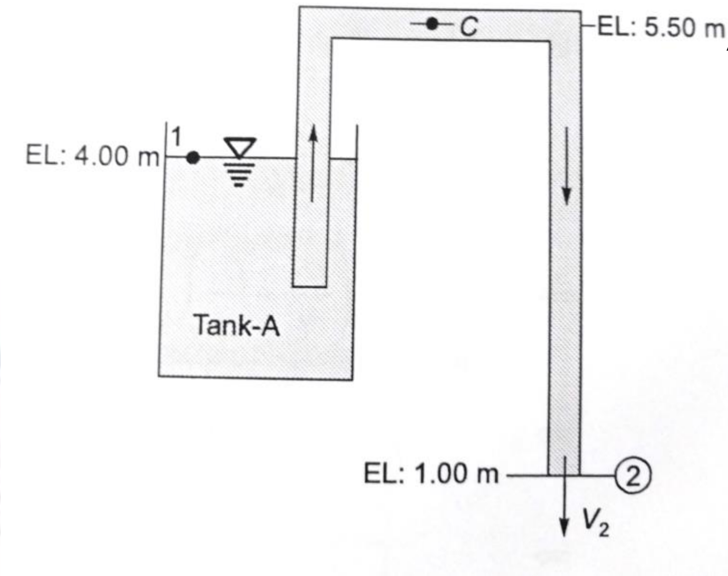
3. For the velocity components u = ay sin(xy) and v = ax sin(xy), obtain an expression for the velocity potential function.

Course Outcome 3

1. Derive the Euler's equation of motion along a streamline and from that derive the Bernouli's equation.

2. Oil of specific gravity 0.8 flows through a 0.2 m diameter pipe under a pressure of 100 KPa. If the datum is 5 m below the center line of the pipe and the total energy with respect to the datum is 35 N m/N. Calculate the discharge.

3. A siphon consisting of a pipe of 15 cm diameter is used to empty kerosene oil (relative density=0.8) from tank A. The siphon discharges to the atmosphere at an elevation of 1.00 m. The oil surface in the tank is at an elevation of 4.00 m. The center line of the siphon pipe at its highest point C is at an elevation of 5.50 m. Estimate,



(a) Discharge in the pipe

(b) Pressure at point C.

Course Outcome 4

1. Differentiate between impulse and reaction turbine.
2. Prove that for a single jet Pelton wheel, the specific speed is given by the relation

$$N_s = 219.78 \frac{d}{D} \sqrt{\eta_o}$$

3. A Pelton wheel having semicircular buckets and working under a head of 120 m is running at 500 rpm. The discharge through the nozzle is 40 L/s and the diameter of the wheel is 50 cm. Find the following:

   (a) The power available at the nozzle.

   (b) Hydraulic efficiency of the wheel, if coefficient of velocity is 0.96.

Course Outcome 5

1. Distinguis between positive displacement pump and roto dynamic pump
2. Expalin the phenomenon of cavitation and methods to avoid it
3. Explain the significance of NPSH in the installation of a centrifugal pump

SYLLABUS

Module 1

Fundamental concepts: Properties of fluid - density, specific weight, viscosity, surface tension, capillarity, vapour pressure, bulk modulus, compressibility, velocity, rate of shear strain, Newton's law of viscosity, Newtonian and non-Newtonian fluids, real and ideal fluids, incompressible and compressible fluids.

Module 2

Fluid statics: Atmospheric pressure, gauge pressure and absolute pressure. Pascal's Law, measurement of pressure - piezo meter, manometers, pressure gauges, energies in flowing fluid, head - pressure, dynamic, static and total head, forces on planar surfaces immersed in fluids, centre of pressure, buoyancy, equilibrium of floating bodies, metacentre and metacentric height.

Fluid kinematics and dynamics: Classification of flow -1D, 2D and 3D flow, steady, unsteady, uniform, non-uniform, rotational, irrotational, laminar and turbulent flow, path line, streak line and stream line.

Module 3

Continuity equation, Euler's equation, Bernoulli's equation. Reynolds experiment, Reynold's number. Hagen- Poiseuille equation, head loss due to friction, friction, Darcy- Weisbach equation, Chezy's formula, compounding pipes, branching of pipes, siphon effect, water hammer transmission of power through pipes (simple problems) .

Flow rate measurements- venturi and orifice meters, notches and weirs (description only for notches, weirs and meters), practical applications, velocity measurements- Pitot tube and Pitot – static tube.

Module 4

Hydraulic turbines : Impact of jets on vanes - flat, curved, stationary and moving vanes - radial flow over vanes. Impulse and Reaction Turbines – Pelton Wheel constructional features - speed ratio, jet ratio & work done , losses and efficiencies, inward and outward flow reaction turbines- Francis turbine constructional features, work done and efficiencies – axial flow turbine (Kaplan) constructional features, work done and efficiencies, draft tubes, surge tanks, cavitation in turbines.

Module 5

Positive displacement pumps: reciprocating pump, indicator diagram, air vessels and their purposes, slip, negative slip and work required and efficiency, effect of acceleration and friction on indicator diagram (no derivations), multi cylinder pumps.

Rotary pumps: –centrifugal pump, working principle, impeller, casings, manometric head, work, efficiency and losses, priming, specific speed, multistage pumps, selection of pumps, pump characteristics.

Text Books

1. Mahesh Kumar, Fluid Mechanics and Machines, Pearson, 1st edition, 2019.

2. Pati, S., Textbook of Fluid Mechanics and Hydraulic Machines, Tata McGraw Hill, 1st Edition, 2017.

Reference Books

1. Cimbala & Cengel, Fluid Mechanics: Fundamentals and Applications (4th edition, SIE) , McGraw Hill, 2019

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures
1		
1.1	Fundamental concepts: Properties of fluid - density, specific weight, viscosity, surface tension, capillarity, vapour pressure	3
1.2	Bulk modulus, compressibility, velocity, rate of shear strain, Newton's law of viscosity	3
1.3	Newtonian and non-Newtonian fluids, real and ideal fluids, incompressible and compressible fluids.	3
2		
2.1	Fluid statics: Atmospheric pressure, gauge pressure and absolute pressure. Pascal's Law, measurement of pressure - piezo meter, manometers, pressure gauges, energies in flowing fluid	3
2.2	Head - pressure, dynamic, static and total head, forces on planar surfaces immersed in fluids, centre of pressure, buoyancy, equilibrium of floating bodies, metacentre and metacentric height.	3

2.3	Fluid kinematics and dynamics: Classification of flow -1D, 2D and 3D flow, steady, unsteady, uniform, non-uniform, rotational, irrotational, laminar and turbulent flow, path line, streak line and stream line	3
3		
3.1	Continuity equation, Euler's equation, Bernoulli's equation. Reynolds experiment, Reynold's number. Hagen- Poiseuille equation	3
3.2	Head loss due to friction, friction, Darcy- Weisbach equation, Chezy's formula, compounding pipes, branching of pipes, siphon effect, water hammer transmission of power through pipes (simple problems)	3
3.3	Flow rate measurements- venturi and orifice meters, notches and weirs (description only for notches, weirs and meters), practical applications, velocity measurements- Pitot tube and Pitot –static tube	3
4		
4.1	Hydraulic turbines: Impact of jets on vanes - flat, curved, stationary and moving vanes - radial flow over vanes	3
4.2	Impulse and Reaction Turbines – Pelton Wheel constructional features - speed ratio, jet ratio & work done, losses and efficiencies, inward and outward flow reaction turbines- Francis turbine constructional features, work done and efficiencies	3
4.3	Axial flow turbine (Kaplan) constructional features, work done and efficiencies, draft tubes, surge tanks, cavitation in turbines	3
5		
5.1	Positive displacement pumps: reciprocating pump, indicator diagram, air vessels and their purposes	3
5.2	Slip, negative slip and work required and efficiency, effect of acceleration and friction on indicator diagram (no derivations), multi cylinder pumps	3
5.3	Rotary pumps: –centrifugal pump, working principle, impeller, casings, manometric head, work, efficiency and losses, priming, specific speed, multistage pumps, selection of pumps, pump characteristics	3

MODEL QUESTION PAPER

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

IV SEMESTER B.TECH DEGREE EXAMINATION

MET283: FLUID MECHANICS AND MACHINERY

Maximum: 100 Marks Duration: 3 hours

PART A

Answer all questions, each question carries 3 marks

1. Define a fluid. What is the difference between ideal and real fluid?
2. Explain the phenomena of capillarity, Obtain the expression for capillary rise of a liquid
3. Distinguish between gauge pressure and absolute pressure.Estimate in meters the depth below the surface of a lake at which the pressure is equal to twice atmospheric pressure.
4. Define and distinguish between Streamline Streak line and path line
5. Water escapes from large storage tank through a small drain hole in the bottom.If the water depth is 2m, what is the exit velocity?If a similar tank contained gasoline what would be the exit velocity?
6. Oil of specific gravity 0.8 flows through a 0.2m diameter pipe under a pressure of 100 kN/m^2. If the datum is 5m below the center line of the pipe and the total energy with respect to the datum is 35m, Calculate the discharge.
7. Differentiate between impulse and reaction turbine
8. Explain the functions of Draft tube
9. Define slip and percentage slip of a reciprocating pump, what are the reasons for negative slip.
10. What are the different classifications of centrifugal pump?

(10×3=30 Marks)

PART B

Answer one full question from each module MECHANICAL ENGINEERING

MODULE-I

11. (a) Write a short note on surface tension. Derive expressions for the pressure

    i. within a droplet of water
    ii. inside a soap bubble

(8 marks)

(b) Define the term viscosity,on what factors does it depend and give the units in which it is expressed. (6 marks)

12. (a) A U-tube is made up of two capillaries of bores 1mm and 2.2mm respectively. The tube is held vertically with zero contact angle. It is partially filled with liquid of surface tension 0.06 N/m. If the estimated difference in the level of two menisci is 15mm, determine the mass density of the liquid. (7 marks)

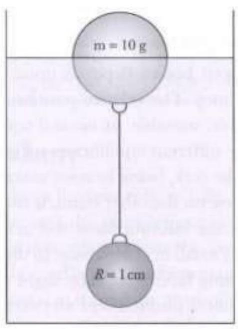
(b) A volume of 3.2 m^3 of certain oil weighs 27.5kN. Calculate its

    i. mass denisty
    ii. weight density
    iii. Specific volume
    iv. Specific gravity

If the kinematic viscosity of the oil is $7 * 10^{-3}$ Stokes, what would be its dynamic viscosity in centipoises. (7 marks)

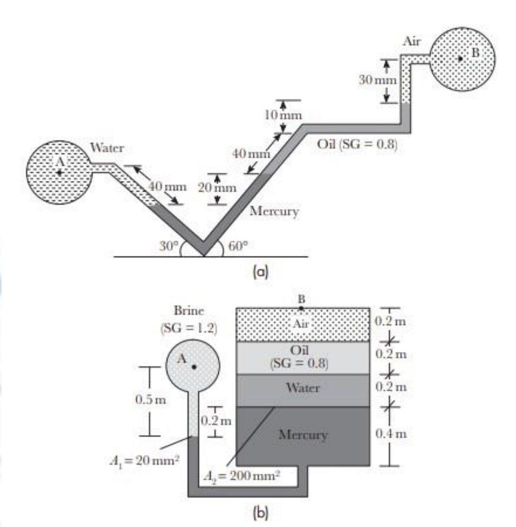
MODULE-II

13. (a) A steel ball of radius 1 cm is hanging inside the water tank by means of a string attached to a hollow plastic ball having raadius 3 cm weighing 10g floating at the free surface, as shown in Fig. Determine the tension in the string and volume of the plastic ball submerged in water. Take density of the steel ball to be 7850 kg/m^2 (7 marks)



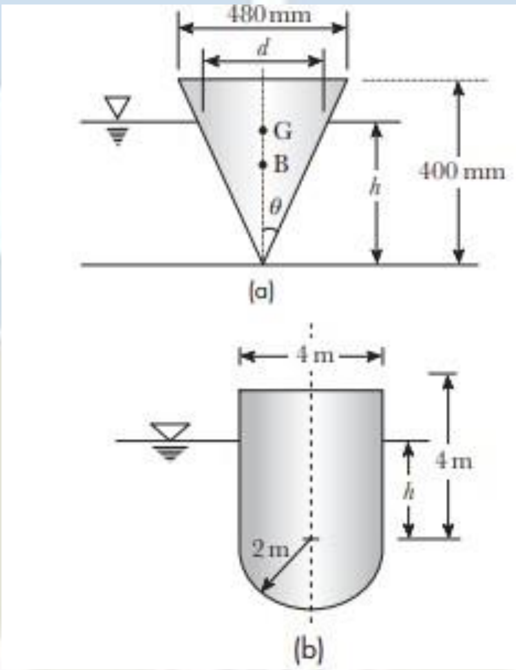
(b) If the velocity distribution for a 2D ideal flow is given by $u = \frac{x}{2+t}$, $v = \frac{y}{1+3t}$ Obtain the equation of (a) the streamlines, (b) the pathlines, and (c) the streaklines that pass through point (1, 2) at t = 0. (7 marks)

14. (a) Find out the pressure difference between points A and B for the manometers shown in the figures



(7 marks)

(b) Check whether the floating objects having specific gravity 0.8 shown in Fig. are stable or not.

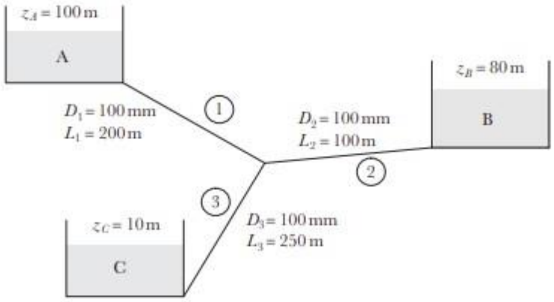


(7 marks)

MODULE-III

15. (a) The maximum velocity for the viscous flow through a 200mm diameter pipe is 3m/s. Determine the average velocity and the radial distance from the pipe axis at which it occurs. In addition, determine the velocity at 25mm from the pipe wall. (7 marks)

(b) Determine the discharge in each branch of the pipe network shown in Fig. Assume same friction factor f = 0.03 in each pipe. (7 marks)



16. (a) Prove that for power transmission through pipes transmission power is maximum when head loss due to friction is one third of the power available at the inlet. (7 marks)

(b) A 5km long water pipeline is used to transmit 200 kW of hydraulic power. If the pressure at the inlet is 6MPa and the pressure drop across the pipe length is 2MPa. Determine the pipe diameter and its transmission efficiency. Take the friction factor f = 0.04 (7 marks)

MODULE-IV

17. (a) A double jet Pelton wheel has a specific speed of 16 and is required to deliver 1200 kW. The turbine is supplied through a pipeline from a reservoir whose level is 380m above the nozzles. Allowing 8% for friction loss in the pipe, calculate the following:

   i. Speed in rpm
   ii. Diameter of the jet
   iii. Mean diameter of the bucket

   Assume $C_v = 0.98$, speed ratio = 0.46, and overall efficiency = 85% (10 marks)

(b) Define the terms unit power, unit speed, ad unit discharge with reference to a hydraulic turbine. (4 marks)

18. (a) Show that the force exerted by a fluid jet in its direction of flow on a semicircular vane is twice that exerted on a flat plate, both plates being fixed in position. (7 marks)

(b) A Keplan turbine runner is to be designed to develop 9000 kW. The net available head is 5.5m. Assume a speed ratio 2, flow ratio 0.65, and total efficiency 85%. The diameter of the boss is 1/3 the diameter of the runner. Find : (7 marks)

   i. Diameter of the runner.
   ii. Speed of the runner.
   iii. Specific speed of the turbine.

MODULE-V

19. (a) Draw the performance curves of a centrifugal pump. Also discuss the effect of blade outlet angles (7 marks)

(b) A centrifugal pump discharges 0.2 m^3/s of water at a head of 25 m when running at a speed of 1400 rpm.The manometric efficiency is 80%. If the impeller has an outer diameter of 30 cm and width of 5 cm, determine the vane angle at the outlet. (7 marks)

20. (a) A single acting reciprocating pump of 200 mm bore and 300 mm stroke runs at 30 rpm. The suction head is 4 m and the delivery head is 15 m. Considering acceleration determine the pressure in the cylinder at the beginning and end of suction and delivery strokes. Take the value of atmospheric pressure as 10.3 m of water head. The length of suction pipe is 8 m and that of delivery pipe is 20 m. The pipe diameters are 120 mm each (7 marks)

(b) The construction details of a centrifugal pump is as follows; Impeller diameter= 50 cm Impeller width=2.5 cm Speed= 1200 rpm Suction head= 6 m Delivery head= 40 m Outlet blade angle= 30°. Manometric efficiency : 80% Overall effrciency :75%. Determine the power required to drive the pump. Also calculate the pressures at the suction and delivery side of the pump. assume the frictional drop in suction is 2 m and in the delivery 8m and inlet swirl as zero (7 marks)

MET 285	MATERIAL SCIENCE AND TECHNOLOGY (MINOR)	CATEGORY	L	T	P	Credits	Year of Introduction
		VAC	4	0	0	4	2019

Preamble:

Understanding the correlation between the chemical bonds and crystal structure of metallic materials.

Recognize the importance of crystal imperfections including dislocations in plastic deformation.

Understanding the mechanisms of materials failure through fatigue and creep.

Understanding the fundamental characteristics of conductors and resistors.

Understanding the fundamental characteristics of semi and super conductors.

Prerequisite: PHT 110 Engineering Physics and CYT 100 Engineering Chemistry

Course Outcomes - At the end of the course students will be able to

CO 1	Understand the basic chemical bonds, crystal structures and their relationship with the properties.
CO 2	How to quantify failure of materials
CO 3	Given a hypothetical or real problem with an electronic materials device or process, explain the cause of the problem and propose solutions.
CO 4	Understand how materials interact at the nanoscale
CO 5	Define and differentiate engineering materials on the basis of structure and properties for engineering applications

Mapping of course outcomes with program outcomes (Minimum requirements)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	-	-	-	-	-	-	-	-		-	-
CO 2	-	3		-	-	-	-	-	-	-	-	-
CO 3		-	-	2	-	-	-	-	-	-	-	-
CO 4		-	-	-	3	-	-	-	-	-	-	-
CO 5	-	-	-	-		-	-	-	-	-	-	2

ASSESSMENT PATTERN

Bloom's taxonomy	Continuous Assessment Tests		End Semester Examination (Marks)
	Test I (Marks)	Test II (Marks)	
Remember	25	25	25
Understand	15	15	15
Apply	30	25	30
Analyze	10	10	10
Evaluate	10	15	10
Create	10	10	10

Mark distribution

Total Marks	CIE marks	ESE marks	ESE duration
150	50	100	3 Hours

Continuous Internal Evaluation (CIE) Pattern:

Attendance	10 marks
Regular class work/tutorials/assignments	15 marks
Continuous Assessment Test (Minimum 2 numbers)	25 marks

End semester pattern:- There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1): Understand the basic chemical bonds, crystal structures and their relationship with the properties.

1. Why ionic and covalent bonded materials are poor conductors? Draw electronic configurations.
2. Correlate the strength of an element with atomic number.
3. What kind of bonding you expect in the following materials: NaCl, Cadmium Telluride and Bronze.
4. Explain how grain size influences the strength of a metal

Course Outcome 2 (CO2): How to quantify failure of materials.

1. Explain the factors affecting the fatigue strength?
2. Explain the effects of crystalline and non-crystalline structure on strength of a metal.
3. What are the roles of surface defects on crack propagation?
4. A small hole is drilled through a steel plate ahead of a crack, whether it can stop the crack's progress until repairs can be made or not? Explain in detail and derive the equation
5. Explain the effect of impact loading on ductile materials

Course Outcome 3 (CO3): Given a hypothetical or real problem with an electronic materials device or process, explain the cause of the problem and propose solutions.

1. Explain why nichrome and not copper is used as a heating element.
2. Why does the conductivity of a semiconductor change with impurity content? Compare this with the behavior of metallic conductors.
3. Explain why lead and zinc with an even number of electrons in the outer shell and a full valence band are conductors.
4. When ice melts into water, the dielectric constant increases, in contrast to the decrease observed during the melting of HCl. Explain why this is so.

Course Outcome 4 (CO4): Understand how materials interact at the nanoscale

1. What is the concept of nano? Correlate the significance of dislocation density to single crystal silicon ICs used in electronic industry.
2. Explain touch screens
3. Explain flexible electronic circuits

Course Outcome 5 (CO5): Define and differentiate engineering materials on the basis of structure and properties for engineering applications

1. Explain the slip systems of BCC, FCC and HCP. Why BCC and HCP exhibit brittle nature and FCC ductile nature?
2. Explain in detail the different strengthening mechanisms of metallic crystals
3. Explain why Aluminum used in long distance transmission lines cannot be strengthened by solid solution.
4. Explain the attributes of surface breakdown of an insulator

SYLLABUS

MODULE - 1

Earlier and present development of atomic structure- primary bonds: - secondary bonds - earlier and present development of atomic structure- primary bonds: - secondary bonds - classification of engineering materials- levels of structure- crystallography- structure–property relationships in materials - classification of engineering materials.

MODULE - II

Miller indices: - modes of plastic deformation - structure determination by X-ray diffraction - Classification of crystal imperfections- Diffusion in solids, fick's laws - dislocation density - mechanism of crystallization: homogeneous and heterogeneous nuclei formation - Hall - Petch theory.

MODULE - III

Phase diagrams: - Limitations of pure metals and need of alloying - classification of alloys, solid solutions, Hume Rothery`s rule - strengthening mechanisms- Fatigue: - Stress cycles – fatigue tests, S-N curve - Ductile to brittle transition temperature (DBTT) in steels - Creep: Creep curves – creep tests - Super plasticity - introduction to super alloys.

MODULE - IV

Composites:- fiber and composite phase - polymer matrix composites - metal matrix composites - ceramic matrix composites - dielectric materials- conductors - resistor materials.

MODULE - V

Superconducting phenomenon - semi conductors- fabrication of integrated circuits - semiconductor devices.

Text Books

1. Callister William. D., Material Science and Engineering, John Wiley, 2014
2. Raghavan V, Material Science and Engineering, Prentice Hall, 2004

Reference

1. Avner H Sidney, Introduction to Physical Metallurgy, Tata McGraw Hill, 2009
2. Anderson J.C. *et.al*., Material Science for Engineers, Chapman and Hall, 1990
3. Dieter George E, Mechanical Metallurgy, Tata McGraw Hill, 1976

MODEL QUESTION PAPER

MATERIAL SCIENCE & TECHNOLOGY - MET 285

Max. Marks : 100 **Duration : 3 Hours**

Part – A

Answer all questions.

Answer all questions, each question carries 3 marks

1. NASA's *Parker Solar Probe* will be the first-ever mission to "touch" the Sun. The spacecraft, about the size of a small car, will travel directly into the Sun's atmosphere about 4 million miles from the earth surface. Postulate the coolant used in the parker solar probe with chemical bonds.
2. Distinguish between crystal and non crystalline materials.
3. What is the driving force for diffusion?
4. What are the roles of surface imperfections on crack initiation?
5. What is the grain size preferred for creep applications? Why
6. Explain the attributes of DBTT
7. Make a list of at least four different sports implements that are made of or contain composites
8. What is the distinction between matrix and dispersed phases in a composite material?
9. Specify three elements that you would add to pure silicon to make it an extrinsic semiconductor of (i) the *n*-type, and (ii) the *p*-type.
10. Explain why nichrome and not copper is used as a heating element

PART -B

Answer one full question from each module.

Module -1

11. Calculate the APF of SC, BCC and FCC (14 marks).

OR

12. Distinguish between characteristics of ionic, covalent ad metallic bonds (14 marks).

Module -2

13. Explain the effect of: (i) Grain size; (ii) Grain size distribution and (iii) Grain orientation (iv) Grain shape on strength and creep resistance with neat sketches. Attributes of Hall-Petch equation and grain boundaries (14 marks).

OR

14. Distinguish between homogeneous and heterogeneous nuclei formation (14 marks).

Module -3

15. Postulate with neat sketches, why 100 % pure metals are weaker? What are the primary functions of alloying? Explain the fundamental rules governing the alloying with neat sketches and how is it accomplished in substitution and interstitial solid solutions? (14 marks).

OR

16. Explain fatigue test and attributes of S-N curve (14 marks).

Module -4

17. For a polymer-matrix fiber-reinforced composite, (a) list three functions of the matrix phase; (b) Compare the desired mechanical characteristics of matrix and fiber phases; and (c) cite two reasons why there must be a strong bond between fiber and matrix at their interface (14 marks).

OR

18. The dielectric constant of polyethylene is independent of temperature, while that of polyvinylchloride is not. Explain this difference in behavior on the basis of their monomer structures (14 marks).

Module -5

19. (a) Derive the kinetic energy of free electrons as a function of their wave number (7 marks).
(b) The resistivity of silver at room temperature is 1.6 x 10^{-8} ohm m. Calculate the collision Time for electron scattering (7 marks).

OR

20. (a). Explain why lead and zinc with an even number of electrons in the outer shell and a full valence band are conductors (7 marks).
(b). Calculate the fraction of holes present at 300 K in silicon doped with indium. The acceptor level is 0.16 eV above the top of the valence band (7 marks).

Course content and lecture schedules.

Module	TOPIC	No. of hours	Course outcomes
1.1	Earlier and present development of atomic structure; correlation of atomic radius to strength; electron configurations; - Primary bonds: - characteristics of covalent, ionic and metallic bond - properties from bonding.	2	CO1
1.2	Secondary bonds: - classification- hydrogen bond and anomalous behavior of ice float on water, application- specific heat, applications.	2	
1.3	Classification of engineering materials- levels of structure-crystallography:- crystal, space lattice, unit cell- APF of BCC, FCC, HCP structures.	2	
1.4	short and long range order - non crystalline - structure–property relationships in materials.	1	
2.1	Miller indices: - crystal plane and direction - attributes of miller indices for slip system, brittleness of BCC, HCP and ductility of FCC - modes of plastic deformation: - slip and twinning - structure determination by X-ray diffraction.	3	CO1 CO2
2.2	Classification of crystal imperfections: - types of point and dislocations.- Diffusion in solids, fick's laws, mechanisms, applications - dislocation density and attributes of nano structures.	3	

2.3	Mechanism of crystallization: Homogeneous and heterogeneous nuclei formation, under cooling, dendritic growth, grain boundary irregularity.	1	CO1 CO2
2.4	Effects of grain size, grain size distribution, grain shape, grain orientation on dislocation/strength and creep resistance - Hall - Petch theory.	2	
3.1	Phase diagrams: - Limitations of pure metals and need of alloying - classification of alloys, solid solutions, Hume Rothery`s rule - strengthening mechanisms.	3	CO2 CO5
3.2	Fatigue: - Stress cycles – Primary and secondary stress raisers - Characteristics of fatigue failure, fatigue tests, S-N curve attributes.	2	
3.3	Factors affecting fatigue strength: stress concentration, size effect, surface roughness, change in surface properties, surface residual stress - Ways to improve fatigue life.	2	
3.4	Ductile to brittle transition temperature (DBTT) in steels -Creep: Creep curves – creep tests - Super plasticity - introduction to nickel based super alloys, characteristics and applications.	2	CO1 CO2
4.1	Composites:- fiber and composite phase - polymer matrix composites - metal matrix composites - ceramic matrix composites	2	
4.2	Dielectric materials:- polarization, temperature and frequency effects, electric breakdown, ferroelectric materials.	3	CO1 CO2
4.3	Conductors: - the resistivity range, free electron theory.	2	
4.4	Conduction by free electrons, conductor and resistor materials.	2	
5.1	Superconducting phenomenon, Type I and Type II superconductors, potential applications.	3	CO3
5.2	Semi conductors:- energy gap in solids, intrinsic and extrinsic semiconductors, semiconductor materials.	2	
5.3	Fabrication of integrated circuits: - production of metallurgical grade silicon, semiconductor grade silicon, single crystal growth, wafer manufacture, oxidation, photolithography, doping.	3	CO4
5.4	Ion implantation, epitaxial growth, metallization.	1	
5.5	Some semiconductor devices: - junction diodes, lasers and transistor, photon detectors.	2	CO4

SEMESTER -4

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
MET202	ENGINEERING THERMODYNAMICS	PCC	3	1	-	4

Preamble :

Thermodynamics is the study of energy . Without energy life cannot exist. Activities from breathing to the launching of rockets involves energy transactions and are subject to thermodynamic analysis. Engineering devices like engines, turbines, refrigeration and air conditioning systems, propulsion systems etc., work on energy transformations and must be analysed using principles of thermodynamics. So, a thorough knowledge of thermodynamic concepts is essential for a mechanical engineer. This course offers an introduction to the basic concepts and laws of thermodynamics.

Prerequisite : NIL

Course Outcomes :

After completion of the course the student will be able to

CO1	Understand basic concepts and laws of thermodynamics
CO2	Conduct first law analysis of open and closed systems
CO3	Determine entropy and availability changes associated with different processes
CO4	Understand the application and limitations of different equations of state
CO5	Determine change in properties of pure substances during phase change processes
CO6	Evaluate properties of ideal gas mixtures

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2										2
CO2	2	2	1	1								1
CO3	3	3	2	2								1
CO4	2	2	2	2								1
CO5	3	3	2	1								1
CO6	3	3	2	2								1

Assessment Pattern

Blooms Category	CA			ESA
	Assignment	Test - 1	Test - 2	
Remember	25	20	20	10
Understand	25	40	40	20
Apply	25	40	40	70
Analyse	25			
Evaluate				
Create				

Continuous Internal Evaluation Pattern:

Attendance : 10 marks

Continuous Assessment Test (2 numbers) : 25 marks

Assignment/Quiz/Course project : 15 marks

Mark distribution & Duration of Examination :

Total Marks	CA	ESE	ESE Duration
150	50	100	3 Hours

End semester pattern:

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

COURSE LEVEL ASSESSMENT QUESTIONS

Course Outcome 1

1. Discuss the limitations of first law of thermodynamics.

2. Second law of thermodynamics is often called a directional law . Why?

3. Explain Joule-Kelvin effect. What is the significance of the inversion curve ?

Course Outcome 2

1. A mass of 2.4 kg of air at 150 kPa and 12°C is contained in a gas – tight, frictionless piston – cylinder device. The air is now compressed to a final pressure of 600 kPa . During this process, heat is transferred from the air such that the temperature inside the cylinder remains constant. Calculate the work input during this process.

2. Carbon dioxide enters an adiabatic nozzle steadily at 1 MPa and 500°C with a mass flow rate of 600 kg/hr and leaves at 100 kPa and 450 m/s. The inlet area of the nozzle is 40 cm^2. Determine (a) the inlet velocity and (b) the exit temperature

3. A vertical piston – cylinder device initially contains 0.25 m^3 of air at 600 kPa and 300°C. A valve connected to the cylinder is now opened and air is allowed to escape until three-quarters of the mass leave the cylinder at which point the volume is 0.05 m^3. Determine the final temperature in the cylinder and the boundary work during this process.

Course Outcome 3

1. An adiabatic vessel contains 2 kg of water at 25˚C. B paddle – wheel work transfer, the temperature of water is increased to 30˚C. If the specific heat of water is assumed to be constant at 4.186 kJ/kg.K, find the entropy change of the universe.

2. Two kilograms of water at 80°C is mixed adiabatically with 3 kg of water at 30°C in a constant pressure process at 1 atm. Find the increase in entropy of the total mass of water due to the mixing process.

3. Argon enters an insulated turbine operating under steady state at 1000˚C and 2 MPa and exhausts at 350 kPa. The mass flow rate is 0.5 kg/s and the turbine develops power at the rate of 120 kW. Determine (a)the temperature of the argon at the turbine exit, (b) the irreversibility of the turbine and (c) the second law efficiency. Neglect KE and PE effects. Take T_o = 20˚C and P_o = 1 bar

Course Outcome 4

1. What are the limitations of ideal gas equation and how does Van der Waals equation overcome these limitations ?

2. Discuss law of corresponding states and its role in the construction of compressibility chart.

3. A rigid tank contains 2 kmol of N_2 and 6 kmol of CH_4 gases at 200 K and 12 MPa. Estimate the volume of the tank, using (a) ideal gas equation of state (b) the compressibility chart and Amagat's law

Course Outcome 5

1. Steam is throttled from 3 MPa and 600˚C to 2.5 MPa. Determine the temperature of the steam at the end of the throttling process.

2. Determine the change in specific volume, specific enthalpy and quality of steam as saturated steam at 15 bar expands isentropically to 1 bar. Use steam tables

3. Estimate the enthalpy of vapourization of steam at 500 kPa, using the Clapeyron equation and compare it with the tabulated value

Course Outcome 6

1. A gaseous mixture contains , by volume, 21%nitrogen, 50% hydrogen and 29 % carbon dioxide. Calculate the molecular weight of the mixture, the characteristic gas constant of the mixture and the value of the reversible adiabatic expansion index - γ. At 10˚C, the C_p values of nitrogen, hydrogen and carbon dioxide are 1.039, 14.235 and 0.828 kJ/kg.K respectively.

2. A mixture of 2 kmol of CO_2 and 3 kmol of air is contained in a tank at 199 kPa and 20˚C. Treating air to be a mixture of 79% N_2 and 21% O_2 by volume , calculate (a) the individual mass of CO_2 , N_2 and O_2, (b) the percentage content of carbon by mass in the mixture and (c) the molar mass , characteristic gas constant and the specific volume of the mixture

3. A gas mixture in an engine cylinder has 12% CO_2, 11.5 % O_2 and 76.5% N_2 by volume. The mixture at 1000˚C expands reversibly, according to the law $PV^{1.25}$ = constant, to 7 times its initial volume. Determine the work transfer and heat transfer per unit mass of the mixture.

SYLLABUS

Module 1: Role of Thermodynamics and it's applications in Engineering and Science –Basic Concepts Macroscopic and Microscopic viewpoints, Concept of Continuum, Thermodynamic System and Control Volume, Surrounding, Boundaries, Types of Systems, Universe, Thermodynamic properties, Process, Cycle, Thermodynamic Equilibrium, Quasi – static Process, State, Point and Path function. Zeroth Law of Thermodynamics, Measurement of Temperature, reference Points, Temperature Scales.

Module 2: Energy - Work - Pdv work and other types of work transfer, free expansion work, heat and heat capacity. Joule's Experiment- First law of Thermodynamics - First law applied to Non flow Process- Enthalpy- specific heats- PMM1, First law applied to Flow Process, Mass and Energy balance in simple steady flow process. Applications of SFEE, Transient flow –Filling and Emptying Process, Limitations of the First Law.

Module 3: Second Law of Thermodynamics, Thermal Reservoir, Heat Engine, Heat pump – Kelvin-Planck and Clausius Statements, Equivalence of two statements, Reversibility, Irreversible Process, Causes of Irreversibility, PMM2, Carnot's theorem and its corollaries, Absolute Thermodynamic Temperature scale. Clausius Inequality, Entropy- Entropy changes in various thermodynamic processes, principle of increase of entropy and its applications, Entropy generation, Entropy and Disorder, Reversible adiabatic process- isentropic process, Third law of thermodynamics, Available Energy, Availability and Irreversibility- Second law efficiency.

Module 4: Pure Substances, Phase Transformations, Triple point, properties during change of phase, T-v, p-v and p-T diagram of pure substance, p-v-T surface, Saturation pressure and Temperature, T-h and T-s diagrams, h-s diagrams or Mollier Charts, Dryness Fraction, steam tables. Property calculations using steam tables. The ideal Gas Equation, Characteristic and Universal Gas constants, Deviations from ideal Gas Model: Equation of state of real substances, Vander Waals Equation of State, Virial Expansion, Compressibility factor, Law of corresponding state, Compressibility charts.

Module 5: Mixtures of ideal Gases – Mole Fraction, Mass fraction, Gravimetric and volumetric Analysis, Dalton's Law of partial pressure, Amagat's Laws of additive volumes, Gibbs-Dalton's law Equivalent Gas constant and Molecular Weight, Properties of gas mixtures: Internal Energy, Enthalpy, specific heats and Entropy, Introduction to real gas mixtures- Kay's rule. General Thermodynamic Relations – Combined First and Second law equations – Helmholtz and Gibb's functions - Maxwell's Relations, Tds Equations. The Clapeyron Equation, equations for internal energy, enthalpy and entropy, specific heats, Throttling process, Joule Thomson Coefficient, inversion curve.

Text Books

1. P. K. Nag, Engineering Thermodynamics, McGraw Hill, 2013

2. E. Rathakrishnan Fundamentals of Engineering Thermodynamics, PHI, 2005

3. Y. A. Cengel and M. A. Boles, Thermodynamics an Engineering Approach, McGraw Hill, 2011

Reference Books:

1. Moran J., Shapiro N. M., Fundamentals of Engineering Thermodynamics, Wiley, 2006

2. R. E. Sonntag and C. Borgnakke, Fundamentals of Thermodynamics, Wiley, 2009

3. Holman J. P. Thermodynamics, McGraw Hill, 2004

4. M. Achuthan, Engineering Thermodynamics, PHI, 2004

COURSE PLAN

Module	Topics	Hours Allotted
1	Role of Thermodynamics and it's applications in Engineering and Science – Basic Concepts Macroscopic and Microscopic viewpoints, Concept of Continuum, Thermodynamic System and Control Volume, Surrounding, Boundaries, Types of Systems, Universe	1L
	Thermodynamic properties, Process, Cycle, Thermodynamic Equilibrium, Quasi – static Process, State, Point and Path function.	1L
	Zeroth Law of Thermodynamics, Measurement of Temperature, reference Points, Temperature Scales.	2L + 1T
2	Energy - Work - Pdv work and other types of work transfer, free expansion work, heat and heat capacity.	2L + 1T
	Joule's Experiment- First law of Thermodynamics - First law applied to Non flow Process- Enthalpy- specific heats- PMM1	2L + 1T
	First law applied to Flow Process, Mass and Energy balance in simple steady flow process. Applications of SFEE	2L + 1T
	Transient flow –Filling and Emptying Process, Limitations of the First Law.	1L + 1T
3	Second Law of Thermodynamics, Thermal Reservoir, Heat Engine, Heat pump – Kelvin-Planck and Clausius Statements, Equivalence of two statements	2L
	Reversibility, Irreversible Process, Causes of Irreversibility, PMM2, Carnot's theorem and its corollaries, Absolute Thermodynamic Temperature scale.	2L + 1T
	Clausius Inequality, Entropy- Entropy changes in various thermodynamic processes, principle of increase of entropy and its applications, Entropy generation, Entropy and Disorder, Reversible adiabatic process- isentropic process, Third law of thermodynamics	2L + 1T
	Available Energy, Availability and Irreversibility- Second law efficiency.	2L + 1T
	Pure Substances, Phase Transformations, Triple point, properties during change of phase, T-v, p-v and p-T diagram of pure substance, p-v-T surface,	2L

4	Saturation pressure and Temperature, T-h and T-s diagrams, h-s diagrams or Mollier Charts, Dryness Fraction, steam tables. Property calculations using steam tables	2L + 1T
	The ideal Gas Equation, Characteristic and Universal Gas constants, Deviations from ideal Gas Model: Equation of state of real substances, Vander Waals Equation of State, Virial Expansion, Compressibility factor, Law of corresponding state, Compressibility charts.	2L +1T
5	Mixtures of ideal Gases – Mole Fraction, Mass fraction, Gravimetric and volumetric Analysis, Dalton's Law of partial pressure, Amagat's Laws of additive volumes, Gibbs-Dalton's law.	2L
	Equivalent Gas constant and Molecular Weight, Properties of gas mixtures: Internal Energy, Enthalpy, specific heats and Entropy	1L +1T
	Introduction to real gas mixtures- Kay's rule	1L
	General Thermodynamic Relations – Combined First and Second law equations – Helmholtz and Gibb's functions - Maxwell's Relations	2L
	Tds Equations. The Clapeyron Equation, equations for internal energy, enthalpy and entropy, specific heats, Throttling process, Joule Thomson Coefficient, inversion curve.	2L + 1T

MODEL QUESTION PAPER

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FOURTH SEMESTER B.TECH DEGREE EXAMINATION

Course Code : MET202

Course Name : ENGINEERING THERMODYNAMICS

(Permitted to use Steam Tables and Mollier Chart)

Max. Marks : 100 Duration : 3 Hours

Part – A

Answer all questions.

1. Define thermodynamics. List a few of its applications

2.Differentiate between intensive and extensive properties.

3. Differentiate between heat and work.

4. Explain system approach and control volume approach as applied in the analysis of a flow process.

5. An inventor claims to have developed an engine that delivers 26 kJ of work using 82 kJ of heat while operating between temperatures 120°C and 30°C. Is his claim valid ? Give the reason for your answer.

6. Show that two reversible adiabatics cannot intersect

7.Define (i)critical point and (ii) triple point, with respect to water

8. Why do real gases deviate from ideal gas behaviour? When do they approach ideal behaviour?

9. Define Helmholtz function and Gibbs function and state their significance

10. Explain Kay's rule of real gas mixtures

(3 x 10 = 30 marks)

Part – B

Answer one full question from each module.

Module - 1

11.a] Explain macroscopic and microscopic approach to thermodynamics . (7 marks) b] With the aid of a suitable diagram, explain the working of constant volume gas thermometer. (7 marks)

OR

12.a] What is meant by thermodynamic equilibrium ? What are the essential conditions for a system to be in thermodynamic equilibrium ? (7 marks)

b] Express the temperature of 91^{o}C in (i) Farenhiet (ii) Kelvin (iii) Rankine. (7 marks)

Module – 2

13.a] A mass of 2.4 kg of air at 150 kPa and 12°C is contained in a gas – tight, frictionless piston – cylinder device. The air is now compressed to a final pressure of 600 kPa . During this process, heat is transferred from the air such that the temperature inside the cylinder remains constant. Calculate the work input during this process. (7 marks)

b] A 2 m^3 rigid tank initially contains air at 100 kPa and 22^{o}C. The tank is connected to a supply line through a valve. Air is flowing in the supply line at 600 kPa and 22^{o}C. The valve is opened, and air is allowed to enter the tank until the pressure in the tank reaches the line pressure, at which point the valve is closed. A thermometer placed in the tank indicates that the air temperature at the final state is 77^{o}C. Determine, (i) the mass of air that has entered the tank and (ii) the amount of heat transfer. (7 marks)

OR

14.a] A turbine operates under steady flow conditions, receiving steam at the following conditions : pressure 1.2 MPa, temperature 188°C, enthalpy 2785 kJ/kg, velocity 33.3 m/s and elevation 3m. The steam leaves the turbine at the following conditions : pressure 20 kPa, enthalpy 25kJ/kg, velocity 100 m/s, and elevation 0 m. Heat is lost to the surroundings at the rate of 0.29 kJ/s. If the rate of steam flow through the turbine is 0.42 kg/s, what is the power output of the turbine in kW ? (7 marks)

b] State the general energy balance equation for an unsteady flow system and from it, derive the energy balance equation for a bottle filling process, stating all assumptions. (7 marks)

Module – 3

15.a]State the Kelvin-Planck and Clausisus statements of the second law of thermodynamics and prove their equivalence. (7 marks)

b]A heat engine operating between two reservoirs at 1000 K and 300 K is used to drive a heat pump which extracts heat from the reservoir at 300 K at a rate twice that at which the engine rejects heat to it. If the efficiency of the engine is 40 % of the maximum possible and the COP of the heat pump is 50 % of the maximum possible, what is the temperature of the reservoir to which the heat pump rejects heat ? What is the rate of heat rejection from the heat pump, if the rate of heat supply to the engine is 50kW ? (7 marks)

OR

16.a] A house is to be maintained at 21°C during winter and at 26°C during summer. Heat leakage through the walls, windows and roof is about 3000 kJ/hr per degree temperature difference between the interior of the house and the environment. A reversible heat pump is proposed for realising the desired heating and cooling. What is the minimum power required to run the heat pump in the reverse, if the outside temperature during summer is 36°C? Also find the lowest environment temperature during winter for which the inside of the house can be maintained at 21°C consuming the same power. (7 marks)

b] Air enters a compressor in steady flow at 140 kPa, 17°C and 70 m/s and leaves at 350 kPa, 127°C and 110 m/s. The environment is at 100 kPa and 7°C. Calculate per kg of air (a) the actual work required (b) the minimum work required and (c) the irreversibility of the process. (7 marks)

Module – 4

17.a]Show the constant pressure transformation of unit mass of ice at atmospheric pressure and -20^oC to superheated steam at 220^oC on P-v , T-v and P-T coordinate systems and explain their salient features . (7 marks)

b] A rigid vessel of volume 0.3 m^3 contains 10 kg of oxygen at 300 K. Using (i) the perfect gas equation and (ii) the Van der Waal's equation of state, determine the pressure of oxygen in the vessel. Take the Van der Waal's constants for oxygen as a =0.1382 m^6 Pa/ mol^2 and b=0.03186 m^3/ kmol . (7 marks)

OR

18.a]Steam at 25 bar and 300^oC expands isentropically to 5 bar. Calculate the change in enthalpy, volume and temperature of unit mass of steam during this process using steam tables and Mollier chart and compare the values (7 marks)

b]Explain law of corresponding states and its significance to the generalized compressibility chart. (7 marks)

Module – 5

19.a] Derive the expressions for the equivalent molecular weight and characteristic gas constant for a mixture of ideal gases. (6 marks)

b] 0.5 kg of Helium and 0.5 kg of Nitrogen are mixed at 20^oC and at a total pressure of 100 kPa. Find (i) volume of the mixture (ii) partial volumes of the components (iii) partial pressures of the components (iv) the specific heats of the mixture and (v) the gas constant of the mixture. Take ratio of specific heats for Helium and Nitrogen to be 1.667 and 1.4 respectively. (8 marks)

OR

20.a] 2 kg of carbon dioxide at 38°C and 1.4 bar is mixed with 5 kg of nitrogen at 150°C and 1.03 bar to form a mixture at a final pressure of 70 kPa. The process occurs adiabatically in a steady flow apparatus. Calculate the final temperature of the mixture and the change in entropy during the mixing process. Take specific heat at constant pressure for CO_2 and N_2 as 0.85 kJ/kg.K and 1.04 kJ/kg respectively. (7 marks)

b]Derive the Maxwell relations. Explain their significance ? (7 marks)

MET 204	MANUFACTURING PROCESS	CATEGORY	L	T	P	Credits	Year of Introduction
		PCC	**3**	**1**	**0**	**4**	**2019**

Preamble:

1. To gain theoretical and practical knowledge in material casting processes and develops an understanding of the dependent and independent variables which control materials casting in a production processes.
2. Provide a detailed discussion on the welding process and the physics of welding. Introduce students to different welding processes weld testing and advanced processes to be able to appreciate the practical applications of welding.
3. The course will also provide methods of analysis allowing a mathematical/physical description of forming processes.
4. Correlate the material type with the possible fabrication processes
5. Generate solutions to problems that may arise in manufacturing engineering

Prerequisite: MET 205 Metallurgy and material science

Course Outcomes - At the end of the course students will be able to

CO 1	Illustrate the basic principles of foundry practices and special casting processes, their advantages, limitations and applications.
CO 2	Categorize welding processes according to welding principle and material.
CO 3	Understand requirements to achieve sound welded joint while welding different similar and dissimilar engineering materials.
CO 4	Student will estimate the working loads for pressing, forging, wire drawing etc. processes
CO 5	Recommend appropriate part manufacturing processes when provided a set of functional requirements and product development constraints.

Mapping of course outcomes with program outcomes (Minimum requirements)

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**
CO 1	3	-	-	-	-	-	-	-	-		-	-
CO 2	-	-	-	-	-	-	-	-	-	-	-	2
CO 3	-	-	3	-	-	-	-	-	-	-	-	-
CO 4	-	-	-	3	-	-	-	-	-	-	-	-
CO 5	-	4	-	-	-	-	-	-	-	-	-	-

Assessment Pattern

Bloom's taxonomy	Continuous Assessment Tests		End Semester Examination (Marks)
	Test I (Marks)	Test II (Marks)	
Remember	25	25	25
Understand	15	15	15
Apply	30	25	30
Analyse	10	10	10
Evaluate	10	15	10
Create	10	10	10

Mark distribution

Total Marks	CIE marks	ESE marks	ESE duration
150	50	100	3 Hours

Continuous Internal Evaluation (CIE) Pattern:

Attendance	10 marks
Regular class work/tutorials/assignments	15 marks
Continuous Assessment Test (Minimum 2 numbers)	25 marks

End semester pattern:- There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

COURSE LEVEL ASSESSMENT QUESTIONS

Part -A

Course Outcome 1 (CO1): - Illustrate the basic principles of foundry practices and special casting processes, their Advantages, Limitations and Applications

1. Why draft allowances are important for patterns.
2. What are the importances of permeability of molding sand?
3. How runner extension is helpful for good casting quality.
4. Internal corners are more prone to solidification shrinkages than external corners. Explain?
5. Which of the casting processes would be suitable for making small toys in large numbers? Why?

Course Outcome 2 (CO2):

Categorize welding processes according to welding principle and material

1. Why is the quality of welds produced by submerged arc welding very good?
2. What does the strength of a weld nugget in resistance spot welding depends on?
3. What is the strength of a welded joint is inferior or superior to the parent metal? Why?
4. Why some joints may have to be preheated prior to welding.

Part -B

Course Outcome 3 (CO3): Understand requirements to achieve sound welded joint while welding different similar and dissimilar engineering materials.

1. Assume that you are asked to inspect a weld for a critical application. Describe the procedure you would follow. If you find a flaw during your inspection, how would you go about determining whether or not this flaw is important for the particular application?
2. In the building of large ships, there is a need to weld large sections of steel together to form a hull, for this application, which welding process would you select? Why?

Course Outcome 4 (CO4): Student will estimate the working loads for pressing, forging, wire drawing etc. processes

1. How can you tell whether a certain part is forged or cast? Describe the features that you would investigate to arrive at a conclusion.
2. Two solid cylindrical specimens A and B, made of a perfectly plastic material, are being forged with friction and isothermally at room temperature to a reduction in height of 50%. specimen A has a height of 2 inch and cross sectional area of 1 square inch, and specimen B has a height of is 1 inch and a cross sectional area of 2 square inch will the work done be the same for the two specimens? Explain.

Course Outcome 5 (CO5): Recommend appropriate part manufacturing processes when provided a set of functional requirements and product development constraints.

1. Many missile components are made by spinning. What other methods would you use to make missile components if spinning process were not available? Describe the relative advantages and limitations of each method.
2. Suggest a suitable casting process for making an engine piston with Aluminum alloy. What type of mould can be used?
3. Suggest and explain a suitable welding method for welding railway tracks for trains.
4. Suggest a suitable manufacturing process for screw jack, postulate the fundamentals.

SYLLABUS

Module I

Casting:-Characteristics of sand - patterns- cores- -chaplets- simple problems- solidification of metals and Chvorinov's rule - Elements of gating system- risering -chills –simple problems- Special casting process- Defects in castings- Super alloy Production Methods.

Module II

Welding:-welding metallurgy-heat affected zone- grain size and hardness- stress reliving- joint quality -heat treatment of welded joints - weldability - destructive and non destructive tests of welded joints-

Thermit welding, friction welding - Resistance welding: HAZ, process and correlation of process parameters with welded joints - applications of each welding process- Arc welding:-HAZ, process and correlation of process parameters with welded joints- simple problems - applications of each welding process - Oxyacetylene welding:-chemistry, types of flame and its applications - brazing- soldering - adhesive bonding.

Module III

Rolling:- principles - types of rolls and rolling mills - mechanics of flat rolling-Defects-vibration and chatter - flat rolling -miscellaneous rolling process- simple problems - Bulk deformation of metals :- State of stress; yield criteria of Tresca, von Mises, comparisons; Flow rules; power and energy deformations; Heat generation and heat transfer in metal forming process.

Module IV

Forging: methods analysis, applications, die forging, defects in forging - simple problems - Metal extrusion:- metal flow, mechanics of extrusion, miscellaneous process, defects, simple problems, applications - Wire, Rod, and tube drawing:- mechanics of rod and wire drawing, simple problems, drawing defects - swaging, applications – deep drawing.

Module V

Locating and clamping methods- locating methods- locating from plane, circular, irregular surface. Locating methods and devices- simple problems - Basic principles of clamping -Sheet metal operations- Press tool operations-Tension, Compression, tension and compression operations - applications - Fundamentals of die cutting operations - simple problems - types of die construction.

Text Books

1. Donalson cyril, LeCain, Goold, Ghose:- Tool design, McGraw Hill.
2. Serope Kalpakjian, Steven R. Schmid - Manufacturing Engineering and Technology, Pearson.

Reference

1. Joseph R. Davis, S. L. Semiatin, American Society for Metals - ASM Metals Handbook, Vol. 14 Forming and Forging ASM International (1989).
2. Peter Beeley, Foundry Technology, Butterworth-Heinemann
3. Rao P.N., Manufacturing Technology, Volume -1, Tata McGraw Hill.
4. Taylan Altan, Gracious Ngaile, Gangshu Shen - Cold and Hot Forging Fundamentals and Applications - ASM International (2004).
5. Matthew J. Donachie, Stephen J. Donachie, Super alloys A Technical Guide, Second Edition, 2002 ASM International.

MODEL QUESTION PAPER

MANUFACTURING PROCESS - MET 204

Max. Marks : 100 **Duration : 3 Hours**

Part – A

Answer all questions, each question carries 3 marks

1. Why does porosity have detrimental effects on the mechanical properties of castings? Which physical properties like thermal and electrical conductivity also are affected by porosity? explain

2. Large parts cannot be manufactured by the centrifugal casting, comment on the statement.
3. What does the strength of a weld nugget in resistance spot welding depends on?
4. Explain how the atmosphere around the work piece affect the weld obtained in electron beam welding.
5. What is the importance of roll velocity and strip velocity?
6. Explain a suitable rolling process for making threaded fasteners.
7. Explain why forged parts withstand high loads compared to cast parts.
8. Explain why the die pressure in drawing process decreases towards the exit of the die.
9. What is the basic rule for applying clamping forces?
10. What is generally used as the basic reference plane for locating?

PART -B

Answer one full question from each module.

MODULE – 1

11. What is gating ratio? What considerations affect its selection? What are the typical gating ratios for the following applications? (a) Grey iron bed castings made in cast steel, (b) Valve body castings made in cast steel, (c) Aluminum pistons for automobiles, (d) Large gun metal bushes for bearings (14 marks).

OR

12. Explain different types of casting defeats in detail with effects of each defect on quality of the casting (14 marks).

MODULE – 2

13. a. Two plates were welded together and then the strength of the joint was tested. It is found that the weld was stronger than either of the plates. Do you think that the statement is incorrect? Postulate, giving valid reasons with neat sketches (7 marks).

b. what are the methods available for controlling the distortions in welded assembly structure? Describe their relative effects and application(7 marks).

OR

14. a. Two 1-mm thick, flat Copper sheets are being spot welded using a current of 5000A and a current flow time of t=0.18 seconds the electrodes are 5mm in diameter. Estimate the heat generated in the weld zone (7 marks).

b. Explain why some joints may have to be preheated prior to welding? If the parts to be welded are preheated, is the likelihood that porosity will form increased or decreased? Explain(7 marks).

MODULE – 3

15. a. An annealed Copper strip 228mm wide and 25mm thick is rolled to a thickness 20mm in one pass. The roll radius is 300mm and the rolls rotate at 100rpm. Calculate the roll force and the power required in this operation (7 marks).

b. A 100mm square billet is to be rolled into a rod of 12.5mm diameter. Draw the sequence of operations (7 marks).

OR

16. Explain the yield criteria of Tresca, von Mises and compare each other (14 marks).

MODULE – 4

17. a. Explain why crankshaft of an automobile is manufactured by forging and not by casting (7 marks).

b. Estimate the limiting drawing ratio that you would expect from a sheet metal that, when stretched by 23 percentages in length, decreases in thickness by 10 percentages (7 marks).

OR

18. a. Assume that you are reducing the diameter of two round rods, one by simple tension and the other by indirect extrusion. Which methods would be better? Explain (7 marks).

b. A cylindrical specimen made of annealed 4135 steel has a diameter of 6 inches and is 4inch high. It is upset by open die forging with flat dies to a height of 2inch at room temperature. Assuming that the coefficient of friction is 0.2, calculate the force required at the end of the stroke. Use average pressure formula (7 marks).

MODULE – 5

19. Estimate the force required in punching a 25mm diameter hole through a 3.2mm thick annealed Titanium Ti-6Al-4V sheet at room temperature (5 marks).

b. Explain 3-2-1 principle of locating with neat sketches (9 marks).

OR

20. a. determine the die and punch sizes for blanking a circular disc of 20mm diameter from a C20 steel sheet whose thickness is 1.5mm (7 marks).

b. Explain how is unevenness compensated for when locating against an irregular surface with more than three locating points? (7 marks).

Course content and lecture schedules.

Module	TOPIC	No. of hours	Course outcomes
1.1	Casting:-Characteristics of sand -pattern and allowances -type of patterns-cores-core prints-chaplets-simple problems.	2	CO1
1.2	Elements of gating system-gating system, pouring time, choke area -risering Caine's method-chills –simple problems.	2	CO1 CO5
1.3	Special casting process:-shell molding, precision investment, die casting, centrifugal casting, continues casting, squeeze casting surface roughness obtainable and application of each casting process.	2	
1.4	Defects in castings :- Shaping faults arising in pouring, Inclusions and sand defects, Gas defects, Shrinkage defects, Contraction defects, Dimensional errors, Compositional errors and segregation; significance of defects on Mechanical properties . (Kalpakjian, Beeley, Rao).	2	CO1
1.5	Superalloy Production Methods: Vacuum Induction Melting; Electroslag Remelting; Vacuum Arc Remelting (ASM).	1	
2.1	Welding:-welding metallurgy, diffusion, heat affected zone, driving force for grain growth, grain size and hardness- joint quality: porosity, slag inclusions, cracks, surface damage, residual stress lamellar tears, stress reliving, heat treatment of welded joints - weldability (Kalpakjian, Lindberg) - destructive and non destructive tests of welded joints (may be provided as class assignment - Lindberg).	2	CO2

<table>
<tr><td>2.2</td><td>Resistance welding: HAZ, process and correlation of process parameters with welded joints of spot, seam, projection, stud arc, percussion welding- applications of each welding process –simple problems. (Kalpakjian).</td><td>3</td><td>CO2
CO5</td></tr>
<tr><td>2.3</td><td>Arc welding:-HAZ, process and correlation of process parameters with welded joints of shielded metal arc, submerged, gas metal, flux cored, electrogas, electroslag, gas tungsten, plasma arc, electron beam, laser beam –simple problems - Thermit welding, friction welding- applications of each welding process. (Kalpakjian, Lindberg).</td><td>3</td><td rowspan="2">CO2</td></tr>
<tr><td>2.4</td><td>Oxyacetylene welding:-chemistry, types of flame and its applications - brazing- soldering - adhesive bonding.</td><td>1</td></tr>
<tr><td>3.1</td><td>Rolling:- principles - types of rolls and rolling mills - mechanics of flat rolling, roll pressure distribution, neutral point, front and back tension, torque and power, roll forces in hot rolling, friction, deflection and flattening, spreading -– simple problems.</td><td>3</td><td>CO4
CO5</td></tr>
<tr><td>3.2</td><td>rolling defects-vibration and chatter - flat rolling -miscellaneous rolling process: shape, roll forging, ring, thread and gear, rotary tube piercing, tube rolling - applications – simple problems. (Kalpakjian).</td><td>2</td><td rowspan="2">CO4</td></tr>
<tr><td>3.3</td><td>Plastic deformation of metals - stress-strain relationships- State of stress - yield criteria of Tresca, von Mises, and comparisons - applications.</td><td>2</td></tr>
<tr><td>3.4</td><td>Flow rules -power and energy deformations - Heat generation and heat transfer in metal forming process -temperature in forging. (ASM- Taylan Altan).</td><td>1</td><td>CO4</td></tr>
<tr><td rowspan="2">4.1</td><td>Forging: material characterization; grain flow and strength - Forging:- classification - open die forging, forces and work of deformation - Forging methods analysis:- slab method only, solid cylindrical, rectangular work piece in plane strain, forging under sticking condition - simple problems -applications.</td><td>3</td><td rowspan="3">CO4</td></tr>
<tr><td>Deformation zone geometry – die forging: - impression, close, coining, skew rolling etc. –simple problems– defects in forging. (Kalpakjian).</td><td>1</td></tr>
<tr><td>4.2</td><td>Metal extrusion: - metal flow - mechanics of extrusion:-deformation and friction, actual forces, die angle, forces in hot extrusion - miscellaneous process- defects -–simple problems- applications. (Kalpakjian, Lindberg).</td><td>2</td></tr>
<tr><td>4.3</td><td>Wire, Rod, and tube drawing: - mechanics of rod and wire dramwing: deformation, friction, die pressure and angle, temperature, reduction per pass, drawing flat strip and tubes- –simple problems- drawing defects-swaging-applications. (Kalpakjian, Lindberg, Rao).</td><td>2</td><td rowspan="2">CO4</td></tr>
<tr><td>4.4</td><td>Deep drawing- deep drawbility, simple problems - different drawing practices</td><td>1</td></tr>
<tr><td rowspan="2">5.1</td><td>Locating and clamping methods: - basic principle of location; locating methods; degrees of freedom; locating from plane, circular, irregular surface –simple problems.</td><td>2</td><td rowspan="2">CO4</td></tr>
<tr><td>Locating methods and devices: - pin and button locators, rest pads and plates, nest or cavity location.</td><td>1</td></tr>
</table>

5.2	Basic principles of clamping:-strap, cam, screw, latch, wedge, hydraulic and pneumatic clamping –simple problems. (Donaldson, Wilson F.W.).	2	CO4
5.3	Sheet metal operations: Press tool operations: shearing action, shearing operations: blanking, piercing, simple problems, trimming, shaving, nibbing, notching – simple problems - applications.	2	CO4 CO5
5.4	Tension operations: stretch forming - Compression operations: - coining, sizing, ironing, hobbing - tension and compression operations: drawing, spinning, bending, forming, embossing – simple problems- applications. (Donaldson, Wilson F.W., Rao P.N).	2	CO4
	Fundamentals of die cutting operations - inverted, progressive and compound die - simple problems. (Donaldson)	1	

CODE MET206	COURSE NAME FLUID MACHINERY	CATEGORY	L	T	P	CREDIT
		PCC	3	1	-	4

Preamble :

This course provides an understanding of reciprocating and rotary fluid machinery. The course consists of hydraulic pumps, turbines, air compressors and gas turbines

Prerequisite : NIL

Course Outcomes :

After completion of the course the student will be able to

CO1	Explain the characteristics of centrifugal and reciprocating pumps
CO2	Calculate forces and work done by a jet on fixed or moving plate and curved plates
CO3	Explain the working of turbines and Select a turbine for specific application.
CO4	Analyse the working of air compressors and Select the suitable one based on application.
CO5	Analyse gas turbines and Identify the improvements in basic gas turbine cycles.
CO6	Explain the characteristics of centrifugal and reciprocating pumps

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2									
CO2	3	3	2									
CO3	3	3	2									
CO4	3	3	2									
CO5	3	3	2									

Assessment Pattern

Blooms Category	CA			ESA
	Assignment	Test - 1	Test - 2	
Remember	25	20	20	10
Understand	25	40	40	20
Apply	25	40	40	70
Analyse	25			
Evaluate				
Create				

Continuous Internal Evaluation Pattern:

Attendance : 10 marks

Continuous Assessment Test (2 numbers) : 25 marks

Assignment/Quiz/Course project : 15 marks

Mark distribution & Duration of Examination :

Total Marks	CA	ESE	ESE Duration
150	50	100	3 Hours

End semester pattern:

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Outcome 1

1. A centrifugal pump discharges 0.15 m^3/s of water against a head of 12.5 m, the speed of the impeller being 600 r.p.m. The outer and inner diameters of impeller are 500 mm and 250 mm respectively and the vanes are bent back at 35° to the tangent at exit. If the area of flow remains 0.07 m^2 from inlet to outlet, calculate :

    (a) Manometric efficiency of pump,

    (b) Vane angle at inlet, and

    (c) Loss of head at inlet to impeller when discharge is reduced by 40% without changing the speed.

2. (a) What is slip in a reciprocating pump. What is the reason for negative slip in a reciprocating pump.

    (b) A single acting reciprocating pump having a bore of 150 mm and a stroke of 300 mm length, discharges 250 *l* of water per minute at 50 rpm. Neglecting losses, find theoretical discharge and slip of the pump.

    (c) With a neat sketch explain the working of a gear pump.

3. Explain the following terms as they are applied to a centrifugal pump:

    (a) Static suction lift,

    (b) static suction head,

    (c) static discharge head and

    (d) total static head.

Course Outcome 2

1. Prove that the force exerted by a jet of water on a fixed semi-circular plate in the direction of the jet when the jet strikes at the centre of the semi-circular plate is two times the force exerted by the jet on an fixed vertical plate.

2. Show that the angle of swing of a vertical hinged plate is given by

$$\sin\vartheta = \frac{\rho a V^2}{W}$$

    where V = Velocity of the jet striking the plate, a = Area of the jet, and W = Weight of the plate.

3. A jet of water moving at 60 m/s is deflected by a vane moving at 25 m/s in a direction at 30° to the direction of the jet. The water jet leaves the blade normally to the motion of the vanes. Draw the inlet and outlet velocity triangles and find the vane angles for no shock at entry or exit. Take the relative velocity at outlet to be 0.85 of the relative velocity at inlet.

Course Outcome 3

1. Explain the purpose of providing
   (a) scroll casing
   (b) stay vanes
   (c) guide vanes, for a reaction turbine.

2. A Pelton wheel turbine has a mean bucket speed of 12 *m/s* with a jet of water flowing at a rate of 900 *l/s* under a head of 40 m. The bucket deflects the jet at an angle of 165°. Calculate the power given by the water to the runner and the hydraulic efficiency of the turbine. Draw the velocity triangle. Assume the coefficient of velocity to be 0.96.

3. (a) What are the unit quantities used to analyze the performance of hydraulic turbines. Explain its importance.
   (b) What is specific speed of a turbine.

Course Outcome 4

1. With a neat sketch explain the working of centrifugal compressors.

2. An ideal single stage single acting reciprocating compressor logs a displacement volume of 14 litres and a clearance volume of 5%. It intakes air at 1 bar and delivers the same at 7 bar. The compression is polytropic with an index of 1.3 and re-expansion is isentropic with an index of 1.4. Determine the indicated work of a cycle.

3. What is surging in axial flow compressor? What are its effects? Describe briefly.

Course Outcome 5

1. A gas turbine unit operates at a mass flow of 30 *kg/s*. Air enters the compressor at a pressure of 1 bar and temperature 15 $^{\circ}C$ and is discharged from the compressor at a pressure of 10.5 bar. Combustion occurs at constant pressure and results in a temperature rise of 420 K. If the flow leaves the turbine at a pressure of 1.2 bar, determine the net power output from the unit and also the thermal efficiency. Take $C_p = 1.005 kJ/kgK$ and $\gamma = 1.4$.

2. Derive the expression for maximum specific work output of a gas turbine considering machine efficiencies.

3. Write a short note on different type of compression chambers used in a gas turbine engine.

SYLLABUS

Module 1: Impact of jets: Introduction to hydrodynamic thrust of jet on a fixed and moving surface (flat and curve),– Series of vanes - work done and efficiency. Hydraulic Turbines : Impulse and Reaction Turbines – Degree of reaction – Pelton Wheel – Constructional features - Velocity triangles – Euler's equation – Speed ratio, jet ratio and work done, losses and efficiencies, design of Pelton wheel – Inward and outward flow reaction turbines- Francis Turbine – Constructional features – Velocity triangles, work done and efficiencies. Axial flow turbine (Kaplan) Constructional features – Velocity triangles- work done and efficiencies

Module 2: Characteristic curves of turbines – theory of draft tubes – surge tanks – Cavitation in turbines – Governing of turbines – Specific speed of turbine , Type Number– Characteristic curves, scale Laws – Unit speed – Unit discharge and unit power. Rotary motion of liquids – free, forced and spiral vortex flows Rotodynamic pumps- centrifugal pump impeller types,-velocity triangles- manometric head- work, efficiency and losses, H-Q characteristic, typical flow system characteristics, operating point of a pump. Cavitation in centrifugal pumps- NPSH required and available- Type number-Pumps in series and parallel operations. Performance characteristics- Specific speed-Shape numbers – Impeller shapes based on shape numbers.

Module 3: Positive displacement pumps- reciprocating pump – Single acting and double acting- slip, negative slip and work required and efficiency- indicator diagram- acceleration head - effect of acceleration and friction on indicator diagram – speed calculation- Air vessels and their purposes, saving in work done to air vessels multi cylinder pumps. Multistage pumps-selection of pumps- pumping devices-hydraulic ram, Accumulator, Intensifier, Jet pumps, gear pumps, vane pump and lobe pump.

Module 4: Compressors: classification of compressors, reciprocating compressor-single stage compressor, equation for work with and without clearance volume, efficiencies, multistage compressor, intercooler, free air delivered (FAD).
Centrifugal compressor-working, velocity diagram, work done, power required, width of blades of impeller and diffuser, isentropic efficiency, slip factor and pressure coefficient, surging and chocking. Axial flow compressors:- working, velocity diagram, degree of reaction, performance. Roots blower, vane compressor, screw compressor.

Module 5 Gas turbines: classification, Thermodynamic analysis of gas turbine cycles-open, closed and semi closed cycle; ideal working cycle- Brayton cycle-P-v and T-s diagram, thermal efficiency. Effect of compressor and turbine efficiencies. Optimum pressure ratio for maximum specific work output with and without considering machine efficiencies. Comparison of gas turbine and IC engines, Analysis of open cycle gas turbine, Improvements of the basic gas turbine cycles-regeneration, intercooling and reheating-cycle efficiency and work output-Condition for minimum compressor work and maximum turbine work. Combustion chambers for gas turbines. pressure loss in combustion process and stability loop.

Text books

Subramanya, K., Hydraulic Machines, Tata McGraw Hill, 1st edition, 2017

Rathore, M., Thermal Engineering, Tata McGraw Hill, 1st edition, 2010

Reference Books

Ganesan, V., Gas Turbines, Tata McGraw Hill, 3rd edition, 2017.

Sawhney G.S., Thermal and Hydraulic Machines, Prentice Hall India Learning Private Limited; 2nd edition , 2011

COURSE PLAN

Module	Topics	Hours Allotted
I	Impact of jets: Introduction to hydrodynamic thrust of jet on a fixed and moving surface (flat and curve),– Series of vanes - work done and efficiency Hydraulic Turbines : Impulse and Reaction Turbines – Degree of reaction – Pelton Wheel – Constructional features - Velocity triangles – Euler's equation – Speed ratio, jet ratio and work done, losses and efficiencies, design of Pelton wheel – Inward and outward flow reaction turbines- Francis Turbine – Constructional features – Velocity triangles, work done and efficiencies. Axial flow turbine (Kaplan) Constructional features – Velocity triangles- work done and efficiencies	6-3-0
II	Characteristic curves of turbines – theory of draft tubes – surge tanks – Cavitation in turbines – Governing of turbines – Specific speed of turbine , Type Number– Characteristic curves, scale Laws – Unit speed – Unit discharge and unit power. Rotary motion of liquids – free, forced and spiral vortex flows Rotodynamic pumps- centrifugal pump impeller types,-velocity triangles- manometric head- work, efficiency and losses, H-Q characteristic, typical flow system characteristics, operating point of a pump. Cavitation in centrifugal pumps- NPSH required and available- Type number-Pumps in series and parallel operations. Performance characteristics- Specific speed-Shape numbers – Impeller shapes based on shape numbers.	7-2-0
III	Positive displacement pumps- reciprocating pump – Single acting and double acting- slip, negative slip and work required and efficiency- indicator diagram- acceleration head - effect of acceleration and friction on indicator diagram – speed calculation- Air vessels and their purposes, saving in work done to air vessels multi cylinder pumps. Multistage pumps-selection of	7-2-0

	pumps-pumping devices-hydraulic ram, Accumulator, Intensifier, Jet pumps, gear pumps, vane pump and lobe pump.	
IV	Compressors: classification of compressors, reciprocating compressor-single stage compressor, equation for work with and without clearance volume, efficiencies, multistage compressor, intercooler, free air delivered (FAD) Centrifugal compressor-working, velocity diagram, work done, power required, width of blades of impeller and diffuser, isentropic efficiency, slip factor and pressure coefficient, surging and chocking. Axial flow compressors:- working, velocity diagram, degree of reaction, performance. Roots blower, vane compressor, screw compressor.	7-2-0
V	Gas turbines: classification, Thermodynamic analysis of gas turbine cycles-open, closed and semi closed cycle; ideal working cycle- Brayton cycle-P-v and T-s diagram, thermal efficiency. Effect of compressor and turbine efficiencies. Optimum pressure ratio for maximum specific work output with and without considering machine efficiencies. Comparison of gas turbine and IC engines, Analysis of open cycle gas turbine, Improvements of the basic gas turbine cycles-regeneration, intercooling and reheating-cycle efficiency and work output-Condition for minimum compressor work and maximum turbine work. Combustion chambers for gas turbines. pressure loss in combustion process and stability loop.	7-2-0

MODEL QUESTION PAPER

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

IV SEMESTER B.TECH DEGREE EXAMINATION

MET206: FLUID MACHINERY

Mechanical Engineering

Maximum: 100 Marks Duration: 3 hours

PART A

Answer all questions, each question carries 3 marks

1. What is degree of reaction? What will be the degree of reaction for a Pelton wheel.
2. Explain speed ratio and jet ratio.
3. What is governing of a turbine? Why is it important?
4. Explain the term specific speed of a pump. How is it different from specific speed of a turbine.
5. Define slip, percentage slip and negative slip of a reciprocating pump.
6. What is the purpose of air vessels in multi-cylinder reciprocating pump.
7. What are the classifications of compressors? Explain briefly.
8. Write a short note on axial flow compressors. Why is it preferred in aerospace applications.
9. Explain briefly the process of regeneration in a gas turbine engine.
10. Draw the p-v diagram and T-s diagram of Brayton cycle.

(10$\times$3=30 Marks)

PART B

Answer one full question from each module

MODULE-I

11. (a) A 50 mm diameter jet having a velocity of 25 *m/s*, strikes a flat plate, the normal of which is inclined at 30° to the axis of the jet. Calculate the normal force exerted on the plate

    i. when the plate is stationary,
    ii. when the plate is moving with a velocity of 10 *m/s* in the direction of the jet.

    Find also the work done and the efficiency of the jet when the plate is moving. (7 Marks)

(b) A Pelton wheel has a mean bucket speed of 10 *m/s* with a jet of water flowing at the rate of 700 *litres/s* under a head of 30 m. The buckets deflect the jet through an angle of 160°. Calculate the power given by the water to the runner and the hydraulic efficiency of the turbine. Assume coefficient of velocity as 0.98. (7 Marks)

12. (a) A reaction turbine works at 450 rpm under a head of 120 m. Its diameter at inlet is 120 cm and the flow area is 0.4 m^2. The angles made by absolute and relative velocities at inlet are 20° and 60° respectively with the tangential velocity. Determine:

i. The volume flow rate,
ii. The power developed, and
iii. Hydraulic efficiency.

Assume whirl at outlet to be zero. (7 Marks)

(b) A Kaplan turbine runner is to be designed to develop 7357.5 kW shaft power. The net available head is 10 m. Assume that the speed ratio is 1.8 and flow ratio is 0.6. If the overall efficiency is 70% and diameter of the boss is 0.4 times the diameter of the runner, find the diameter of the runner, its speed and specific speed. (7 Marks)

MODULE-II

13. (a) A Pelton wheel is revolving at a speed of 190 rpm and develops 5150.25 kW when working under a head of 220 m with an overall efficiency of 80%. Determine unit speed, unit discharge and unit power. The speed ratio for the turbine is given as 0.47. Find the speed, discharge and power when this turbine is working under a head of 140 m. (7 Marks)

(b) What do you understand by the characteristic curves of a turbine? Describe the important types of characteristic curves. (7 Marks)

14. (a) Why are centrifugal pumps used sometimes in series and sometimes in parallel? Draw the following characteristic curves for a centrifugal pump:
Head, power and efficiency versus discharge with constant speed. (7 Marks)

(b) State the effects of cavitation on the performance of water turbines and also state how to prevent cavitation in water turbines. (7 Marks)

MODULE-III

15. (a) Draw an indicator diagram, considering the effect of acceleration and friction in suction and delivery pipes. Find an expression for the work done per second in case of single-acting reciprocating pump. (7 Marks)

(b) Differentiate :

i. Between a single-acting and double-acting reciprocating pump,
ii. Between a single cylinder and a double cylinder reciprocating pump. (7 Marks)

16. (a) A single-acting reciprocating pump running at 30 r.p.m, delivers 0.012 m^3/s of water. The diameter of the piston is 25 cm and stroke length is 50 cm. Determine :

i. The theoretical discharge of the pump,
ii. Coefficient of discharge, and
iii. Slip and percentage slip of the pump. (8 Marks)

(b) Write a short note on gear pumps. Why gear pump is known as positive displacement pump. (6 Marks)

MODULE-IV

17. (a) With a neat sketch explain the working of an axial flow compressor. (7 Marks)

(b) Derive the expression for the work done in a reciprocating compressor with and without clearance volume. (7 Marks)

18. (a) A single stage double acting air compressor is required to deliver 14 m^3 of air per minute measured at 1.013 bar and 15 $^\circ C$. The delivery pressure is 7 bar and the speed 300 rpm. Take clearance volume as 5% of the swept volume with compression and expansion index n=1.3. Calculate

i. Swept volume of the cylinder,
ii. Delivery temperature,
iii. Indicated power.

(10 Marks)

(b) Draw the velocity diagram of an axial flow compressor. (4 Marks)

MODULE-V

19. (a) The air enters the compressor of an open cycle constant pressure gas turbine at a pressure of 1 bar and temperature 20 $^\circ C$. The pressure of air after compression is 4 bar. The isentropic efficiencies of compressor and turbine are 80% and 85% respectively. The air fuel ratio is 90:1. If flow rate of air is 3.0 *kg/s*, find

i. Power developed
ii. Thermal efficiency of cycle

(7 Marks)

(b) A gas turbine has a pressure ratio of 6:1 and a maximum cycle temperature of 600 $^\circ C$. The isentropic efficiencies of compressor and turbine are 0.82 and 0.85 respectively. Calculate the power output in kW of an electric generator geared to turbine when the air enters the compressor at 15 $^\circ C$ at the rate of 15 *kg/s*. Assume the working fluid to be air with C_p = 1.005 and γ = 1.4. (7 Marks)

20. (a) What are the improvements made to the basic gas turbine cycle. Explain with temperature entropy diagram. (8 Marks)

(b) Differentiate between open, closed and semi closed gas turbine cycles. (6 Marks)

CODE MEL202	COURSE NAME FM & HM LAB	CATEGORY	L	T	P	CREDIT
		PCC	0	0	3	2

Preamble:

This lab is mainly focussed to develop a platform where the students can enhance their engineering knowledge in the fluid mechanics domain by applying their theoretical knowledge acquired.

Prerequisite: MET203 Mechanics of Fluids

Course Outcomes:

After the completion of the course the student will be able to

CO 1	Determine the coefficient of discharge of flow measuring devices (notches, orifice meter and Venturi meter)
CO 2	Calibrate flow measuring devices (notches, orifice meter and Venturi meter)
CO 3	Evaluate the losses in pipes
CO 4	Determine the metacentric height and stability of floating bodies
CO 5	Determine the efficiency and plot the characteristic curves of different types of pumps and turbines

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	2	1						2	3	2		2
CO 2	2	1						2	3	2		2
CO 3	2	1						2	3	2		2
CO 4	2	1						2	3	2		2
CO 5	2	1						2	3	2		2

Assessment Pattern

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	75	75	2.5 hours

Continuous Internal Evaluation Pattern:

Attendance	:	15 marks
Continuous Assessment	:	30 marks
Internal Test (Immediately before the second series test)	:	30 marks

End Semester Examination Pattern: The following guidelines should be followed regarding award of marks

(a) Preliminary work	: 15 Marks
(b) Implementing the work/Conducting the experiment	: 10 Marks
(c) Performance, result and inference (usage of equipments and trouble shooting)	: 25 Marks
(d) Viva voce	: 20 marks
(e) Record	: 5 Marks

General instructions:

Practical examination to be conducted immediately after the second series test covering entire syllabus given below. Evaluation is a serious process that is to be conducted under the equal responsibility of both the internal and external examiners. The number of candidates evaluated per day should not exceed 20. Students shall be allowed for the University examination only on submitting the duly certified record. The external examiner shall endorse the record.

A minimum of 10 experiments are to be performed.

SYLLABUS

LIST OF EXPERIMENTS

1. Determination of coefficient of discharge and calibration of Notches.

2. Determination of coefficient of discharge and calibration of Orifice meter.

3. Determination of coefficient of discharge and calibration of Venturi meter.

4. Determination of hydraulic coefficients of orifices.

5. Determination of Chezy's constant and Darcy's coefficient on pipe friction apparatus.

6. Determine the minor losses in pipe.

7. Experiments on hydraulic ram.

8. Reynolds experiment.

9. Bernoulli's experiment.

10. Determination of metacentric height and radius of gyration of floating bodies.

11. Performance test on positive displacement pumps.

12. Performance test on centrifugal pumps, determination of operating point and efficiency.

13. Performance test on gear pump.

14. Performance test on Impulse turbines.

15. Performance test on reaction turbines (Francis and Kaplan Turbines).

16. Speed variation test on Impulse turbine.

17. Determination of best guide vane opening for Reaction turbine.

18. Impact of jet.

Reference Books

1. Yunus A. Cenegel, John M. Cimbala; Fluid Mechanics- Fundamentals and Applications (in SI Units); McGraw Hill, 2010.
2. Bansal R.K, Fluid Mechanics and Hydraulic Machines (SI Units); Laxmi Publications, 2011.
3. Modi P.N and Seth S.M, “Hydraulics and Fluid Mechanics Including Hydraulic Machines” Standard Book House, New Delhi, 20th Edition, 2015
4. Graebel. W. P, "Engineering Fluid Mechanics", Taylor & Francis, Indian Reprint, 2011
5. Robert W. Fox, Alan T. McDonald, Philip J. Pritchard, “Fluid Mechanics and Machinery”, John Wiley and sons, 2015.
6. J. Frabzini, 'Fluid Mechanics with Engineering Applications', McGraw Hill, 1997.

MEL 204	MACHINE TOOLS LAB- I	CATEGORY	L	T	P	Credits	Year of Introduction
		PCC	0	0	3	2	2019

Preamble:

1. To understand the parts of various machine tools and impart hands on experience on lathe, drilling, shaping, milling, slotting, grinding, tool and cutter grinding machines.
2. To develop knowledge and importance of metal cutting parameters such as feed, velocity and depth of cut etc on cutting force and surface roughness obtainable.
3. To develop fundamental knowledge on tool materials, cutting fluids and tool wear Mechanisms.
4. To apply knowledge of basic mathematics to calculate the machining parameters for different machining processes.
5. To study process parameters and practice on arc and gas welding technologies.
6. To gain knowledge on the structure, properties, heat treatment, testing and applications of ferrous and non ferrous metals.

Prerequisite: MET 204 - Manufacturing Process

Course Outcomes - At the end of the course students will be able to

CO 1	The students can operate different machine tools with understanding of work holders and operating principles to produce different part features to the desired quality.
CO 2	Apply cutting mechanics to metal machining based on cutting force and power consumption.
CO 3	Select appropriate machining processes and process parameters for different metals.
CO 4	Fabricate and assemble various metal components by welding and students will be able to visually examine their work and that of others for discontinuities and defects.
CO 5	Infer the changes in properties of steel on annealing, normalizing, hardening and tempering.

Mapping of course outcomes with program outcomes (Minimum requirements)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	-	-	3	-	-	-	-	-	-	-	-	-
CO 2	-	3	-	-	-	-	-	-	-	-	-	-
CO 3	-	-	-	2	-	-	-	-	-	-	-	-
CO 4	2	-	-	-	-	-	-	-	-	-	-	-
CO 5	-	-	-	-	2	-	-	-	-	-	-	-

Assessment Pattern

Bloom's taxonomy	Continuous Assessment Tests	
	Test 1 (Marks)	Test 2 (Marks)
Remember	20	20
Understand	10	10
Apply	30	30
Analyse	20	20
Evaluate	10	10
Create	10	10

Mark distribution

Total Marks	CIE marks	ESE marks	ESE duration
150	75	75	2.5 Hours

Continuous Internal Evaluation (CIE) Pattern:

Attendance	15 marks
Regular class work/ /Laboratory Record and Class Performance	30 marks
Continuous Assessment Test/s	30 marks
The student's assessment, continuous evaluation, record bonafides, awarding of sessional marks, oral examination etc. should be carried out only by the assistant professor or above. Any two **e**xperiments mentioned in part - B, and any eight experiments in part A and total of minimum of ten experiments are to be performed.	

End semester examination pattern

The Practical Examination will comprise of three hours. Oral examination should be conducted and distribution of marks will be decided by the examiners.

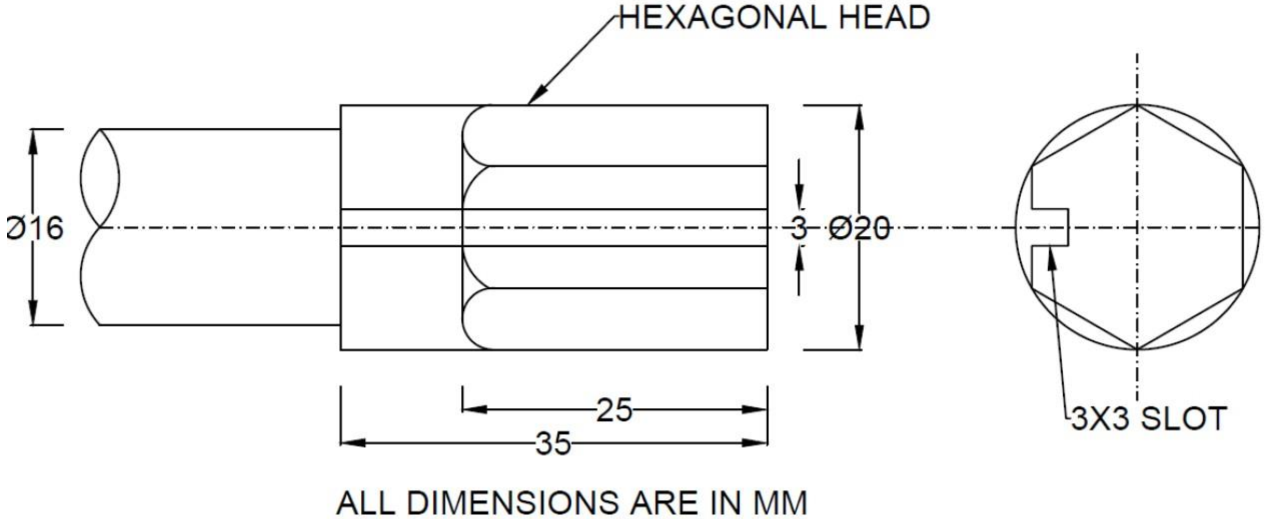
Conduct of University Practical Examinations

The Principals of the concerned Engineering Colleges with the help of the Chairmen/Chairperson will conduct the practical examination with the approval from the University and bonafide work / laboratory record, hall ticket, identity card issued by college are mandatory for appearing practical University examinations. To conduct practical examination, an external examiner and an internal examiner should be appointed by the University.

END SEMESTER EXAMINATION
MODEL QUESTION PAPER

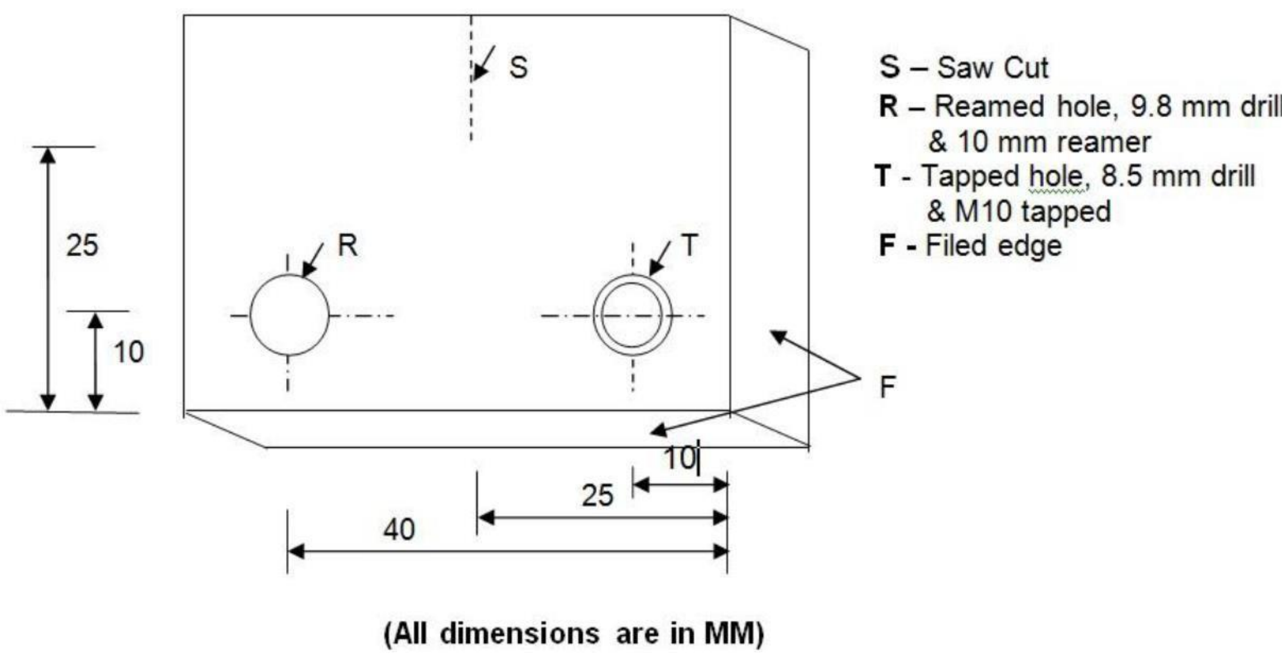
Maximum Marks : 75 **Duration: 2.5 hours**

1. To machine the hexagonal head and the slot shown in the sketch on the specimen and measure the tool wear using toolmaker's microscope.



OR

2. To drill, file, as shown in the sketch, ream and tap holes on the mild steel plate and measure the tool wear using toolmaker's microscope.



OR

3. To make the part shown in the sketch from a mild steel rod on a Lathe and measure the tool flank wear using toolmaker's microscope.

OR

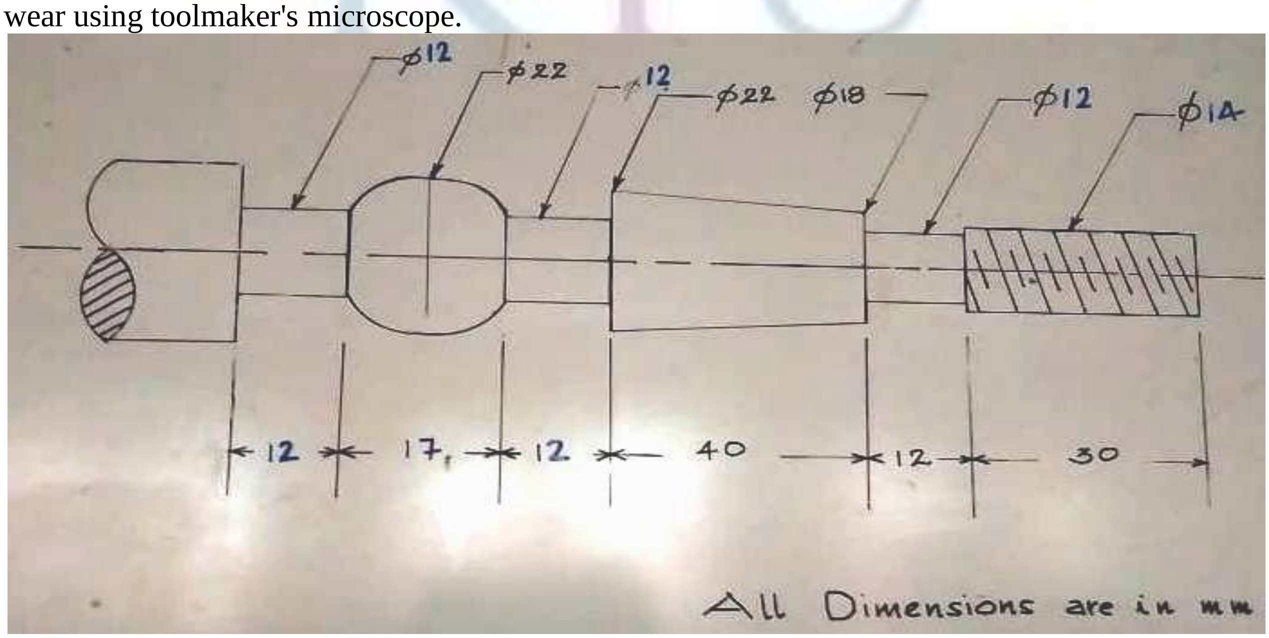
4. Prepare a metallurgical sample and determine the grain size using a optical microscope.

OR

5. To prepare a butt joint with mild steel strip using suitable welding technique and infer on the welded joint.

OR

6. To make the part shown in the sketch from a mild steel rod on a Lathe and measure the tool flank wear using toolmaker's microscope.



SYLLABUS

PART - A

Safety precautions in machine shop - Exercises on machine tools: turning, knurling, drilling, boring, reaming, trepanning, milling, hobbing, planning, shaping, slotting, broaching, grinding, lapping, honing etc. - Welding practice.

PART - B

Metallurgy, heat treatment and testing.

Text Books:

1. Acherkan N. S. “Machine Tool”, Vol. I, II, III and IV, MIR Publications.
2. HMT, Production Technology, Tata McGraw Hill.
3. W. A. J. Chapman, Workshop Technology Part I, ELBS & Edward Arnold Publishers.

Course content and drawing schedules.

<table>
<tr><th></th><th>List of Experiments
A minimum of ten experiments are to be carried out</th><th>Course outcomes</th><th>No. of hours</th></tr>
<tr><td>Experiments</td><td>PART -A
(minimum eight experiments)</td><td></td><td></td></tr>
<tr><td rowspan="1">1</td><td>Centre Lathe
Study of lathe tools: - tool materials - selection of tool for different operations - tool nomenclature and attributes of each tool angles on cutting processes – effect of nose radius, side cutting edge angle, end cutting edge angle and feed on surface roughness obtainable – tool grinding.
• Study the different methods used to observe the work-piece is precisely fixed on lathe.
• Study the optimum aspect ratio of work-piece to avoid vibration and wobbling during turning.
• Machine tool alignment test on lathe.
• Re-sharpening of turning tool to specific geometry</td><td>CO 1</td><td>3</td></tr>
<tr><td rowspan="2">2,3,4,5,6</td><td>Exercises on centre lathe:- Facing, plain turning, step turning and parting – groove cutting, knurling and chamfering - form turning and taper turning – eccentric turning, multi-start thread, square thread and internal thread etc.</td><td rowspan="2">CO 1
CO 2</td><td>3</td></tr>
<tr><td>Exercises on lathe: - Measurement of cutting forces in turning process and correlate the surface roughness obtainable by varying feed, speed, feed, nose radius, side and end cutting edge angles.</td><td>6</td></tr>
</table>

7	Measurement of cutting temperature and tool life in turning and machine tool alignment test on lathe machine.	CO 2	3
86	**Exercises on Drilling machine** • **Exercises on drilling machine**: - drilling, boring, reaming, taping and counter sinking etc. • **Exercises on drilling machine: -** Measurement of cutting forces in drilling process and correlate with process parameters.	CO 1 CO 2	3
9	**Exercises on Shaping machine** • Exercises on shaping machine: - flat surfaces, grooves and key ways. **Exercises on Slotting machine** • Exercises on slotting machine: - flat surfaces, grooves and key ways.	CO 2	3
10	**Planing and Broaching machine** Study and demonstration of broaching and hobbing machine. • Exercises on planing machine	CO 1	3
11	**Exercises on Grinding machine** • Exercise on surface grinding, cylindrical grinding and tool grinding etc. • Measurement of cutting forces and roughness in grinding process and correlate with process parameters. • Study and demonstration of lapping and honing machines.	CO 1	3
12	**Exercises on Welding machine** • Exercises on arc and gas welding: - butt welding and lap welding of M.S. sheets.	CO 4	3
	PART - B - Metallurgy **(minimum two experiments)**	CO 5	6
13	• **Specimen preparation**, etching & microscopic study of Steel, Cast iron and Brass and grain size measurement.		
14	• **Heat treatment study**:–Effect on mechanical properties and microstructure of ferrous and non ferrous metals. • Studies of various quenching mediums, Carryout heat treatments on steel based on ASM handbook vol.4 and observe the hardness obtained.	CO 5	6

SEMESTER -4

MINOR

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
MET282	THEORY OF MACHINES	VAC	3	1	0	4

Preamble:

Goal of this course is to expose the students to the fundamentals of kinematics of mechanisms, design of cams, theory and analysis of gears, gear trains, clutches, brakes. The students will also be exposed to velocity and acceleration analysis of different mechanisms. It provides the knowledge on balancing of rotating and reciprocating masses, Gyroscopes, Energy fluctuation in Machines.

Prerequisite: Nil

Course Outcomes: After the completion of the course the student will be able to

CO 1	Interpret basic principles of mechanisms and machines and Analyse a given mechanism based on velocity and acceleration. List the basic selection requirements of different types of mechanical clutches.
CO 2	Describe the theories of gears and gear trains. List the basic selection requirements of different types of mechanical brakes.
CO 3	Develop the profile of CAMs as per the requirements and to understand cam profile.
CO 4	Explain the dynamic balancing of revolving and reciprocating masses. Describe the fundamentals of gyroscope and its application.
CO 5	Analyse the performance of governors and flywheels.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3	2	2		3						2
CO 2	3	3	2	2		3						2
CO 3	3	3	2	2		3						2
CO 4	3	3	3	2		1						1
CO 5	3	3	3	3		1						3

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember			
Understand	30	40	80
Apply		10	10
Analyse	20		10
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

COURSE LEVEL ASSESSMENT QUESTIONS

Course Outcome 1 (CO1): *Interpret basic principles of mechanisms and machines. Analyse a given mechanism based on velocity and acceleration. List the basic selection requirements of different types of mechanical clutches.*

1. Explain the inversions of a four bar mechanism.
2. Explain with neat sketches, the working of single plate clutch.
3. The crank of a slider crank mechanism rotates clockwise at a constant speed of 300 r.p.m. The crank is 150 mm and the connecting rod is 600 mm long. Determine: 1. Linear velocity and acceleration of the midpoint of the connecting rod, and 2. angular velocity and angular acceleration of the connecting rod, at a crank angle of 45° from inner dead centre position

Course Outcome 2 (CO2) *Describe the theories of gears and gear trains. List the basic selection requirements of different types of mechanical brakes.*

1. State and prove the law of gearing
2. In an epicyclic gear train, an arm carries two gears A and B having 36 and 45 teeth respectively. If the arm rotates at 150 rpm in the anticlockwise direction about the centre of the gear A which is fixed, determine the speed of gear B. If the gear A instead of being fixed makes 300 rpm in the clockwise direction, what will be the speed of gear B?
3. Discuss the various types of the brakes.

Course Outcome 3 (CO3): *Develop the profile of CAMs as per the requirements and and to understand cam profile.*

1. Explain the different classifications of cam and followers.
2. Draw the displacement, velocity and acceleration diagrams when the follower moves in SHM.
3. A cam with 30 mm as minimum diameter is rotating clockwise at a uniform speed of 1200 r.p.m. and has to give the following motion to a roller follower 10 mm in diameter:
   a) Follower to complete outward stroke of 25 mm during 120° of cam rotation with equal uniform acceleration and retardation;
   b) (b) Follower to dwell for 60° of cam rotation;
   c) (c) Follower to return to its initial position during 90° of cam rotation with equal uniform acceleration and retardation;
   d) (d) Follower to dwell for the remaining 90° of cam rotation.

   Draw the cam profile if the axis of the roller follower passes through the axis of the cam.

Course Outcome 4 (CO4): *Explain the static and dynamic balancing of revolving and reciprocating masses. Describe the fundamentals of gyroscope and its application*

1. Four masses m1, m2, m3 and m4 are 200 kg, 300 kg, 240 kg and 260 kg respectively. The corresponding radii of rotation are 0.2 m, 0.15 m, 0.25 m and 0.3 m respectively and the angles between successive masses are 45°, 75° and 135°. Find the position and magnitude of the balance mass required, if its radius of rotation is 0.2 m.

2. Explain with neat sketches, the terms Swaying Couple and Hammer Blow.

3. A ship propelled by a turbine rotor which has a mass of 5000 kg and a speed of 2100 r.p.m. The rotor has a radius of gyration of 0.5 m and rotates in a clockwise direction when viewed from the stern. Find the gyroscopic effects in the following conditions:

   a. The ship sails at a speed of 30 km/h and steers to the left in a curve having 60 m radius.

   b. The ship pitches 6 degree above and 6 degree below the horizontal position. The bow is descending with its maximum velocity. The motion due to pitching is simple harmonic and the periodic time is 20 seconds.

   c. The ship rolls and at a certain instant it has an angular velocity of 0.03 rad/s clockwise when viewed from stern.

   Determine also the maximum angular acceleration during pitching. Explain how the direction of motion due to gyroscopic effect is determined in each case.

Course Outcome 5 (CO5): *Analyse the performance of governors and flywheels.*

1. The turning moment diagram for a petrol engine is drawn to the following scales : Turning moment, 1 mm = 5 N-m ; crank angle, 1 mm = 1°. The turning moment diagram repeats itself at every half revolution of the engine and the areas above and below the mean turning moment line taken in order are 295, 685, 40, 340, 960, 270 mm^2. The rotating parts are equivalent to a mass of 36 kg at a radius of gyration of 150 mm. Determine the coefficient of fluctuation of speed when the engine runs at 1800 r.p.m

2. Explain the different types of governors.

3. The arms of a Porter governor are each 250 mm long and pivoted on the governor axis. The mass of each ball is 5 kg and the mass of the central sleeve is 30 kg. The radius of rotation of the balls is 150 mm when the sleeve begins to rise and reaches a value of 200 mm for maximum speed. Determine the speed range of the governor. If the friction at the sleeve is equivalent of 20 N of load at the sleeve, determine how the speed range is modified.

SYLLABUS

Module 1: Kinematics - Links, mechanism, Degrees of freedom, Grashoff's law. Four-bar chain, Slider crank chain- Inversions and practical applications. Velocity and acceleration diagrams of simple mechanisms. Coriolis acceleration (Theory only). Friction clutch - Pressure and wear theories, pivot and collar friction, Single and multiple disc clutches.

Module 2: Gear – Classification of gears- Gear terminology- Law of gearing, Gear trains - Simple, compound gear trains and epicyclic gear trains. Brakes - Block and band brakes, self-energizing and self-locking in braking.

Module 3: Cams- Types of cams, cam profiles for knife edged and roller followers with and without offsets for SHM, constant acceleration-deceleration, and constant velocity

Module 4: Static and dynamic balancing of rotating mass- Single and several masses in different planes. Balancing of reciprocating mass. Gyroscope –Gyroscopic torque, gyroscopic stabilization of ships and aeroplanes.

Module 5: Governors - Types of governors- simple watt governor - Porter governor- Theory of Proell governor - Isochronism, hunting, sensitivity and stability. Flywheel - Turning moment diagrams, fluctuation of energy

Text Books

1. Ballaney P.L. Theory of Machines, Khanna Publishers,1994

2. S. S. Rattan, Theory of Machines, Tata McGraw Hill, 2009

3. V. P. Singh, Theory of Machines, Dhanpat Rai,2013

Reference Books

1. C. E. Wilson, P. Sadler, Kinematics and Dynamics of Machinery, Pearson Education,2005
2. D. H. Myskza, Machines and Mechanisms Applied Kinematic Analysis, Pearson Education,2013
3. G. Erdman, G. N. Sandor, Mechanism Design: Analysis and synthesis Vol I & II, Prentice Hall of India,1984.
4. Ghosh, A. K. Malik, Theory of Mechanisms and Machines, Affiliated East West Press,1988
5. J. E. Shigley, J. J. Uicker, Theory of Machines and Mechanisms, McGraw Hill,2010
6. Holowenko, Dynamics of Machinery, John Wiley, 1995

COURSE PLAN

No	Topic	No. of Lectures
1	**Module 1 (CO1)**	
1.1	Introduction to link, constrained motions, mechanism, machine	1
1.2	Degrees of freedom, Problem, Grashof's law	1
1.3	Inversion – Four Bar chain – Single Slider Chain – Practical Applications	2
1.4	Velocity Analysis – I Centre Methos – Relative Velocity Method	2
1.5	Acceleration Analysis - Four Bar Mechanism – Single Slider Chain	2
1.6	Corriolis Component of Acceleration –Quick Return Mechanisms	2
1.7	Clutches – Theories - Classifications	1
2	**Module 2 (CO2)**	
2.1	Gear – Classifications – Terminology – Law of Gearing – Velocity of Sliding – Interference - Problems	3
2.2	Gear Train –Classifications - Problems on Epi cyclic gear trains	3
2.3	Brake – Theory – Classifications	2
3	**Module 3 (CO3)**	
3.1	Cam – Introduction - Classifications	1
3.2	Velocity and Acceleration Diagrams – Uniform Velocity – Uniform Acceleration and Deceleration – SHM – Calculations	2
3.3	Construction of Cam Profile	4
4	**Module 4 (CO4)**	
4.1	Static and dynamic balancing of rotating masses –Single and several masses in different planes	2
4.2	Balancing of reciprocating masses	3
4.3	Gyroscope – Introduction – Stabilization of Ships	2
4.4	Stabilization of Air Planes	2
5	**Module 5 (CO5)**	
5.1	Governors – Introduction –Classifications	2
5.2	Analytical Problems	2
5.3	Hunting – Sensitivity – Isochronism -Stability	2
5.4	Flywheels – Turning Moment Diagrams –Fluctuation of Energy	2
5.5	Analytical Problems	2

MODEL QUESTION PAPER

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIFTH SEMESTER B.TECH DEGREE EXAMINATION

Course Code : MET282

Course Name : THEORY OF MACHINES

Max. Marks : 100 Duration : 3 Hours

PART – A

(*ANSWER ALL QUESTIONS, EACH QUESTION CARRIES 3 MARKS*)

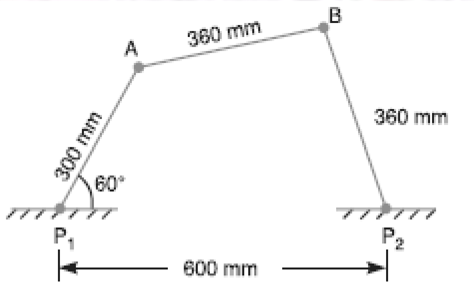
1. Write down the Kutzbach criterion of movability of plane mechanisms. Derive the Grubler's equation from it.
2. Explain the types of constrained motions with neat sketches.
3. With a neat sketch prove the common normal at the point of contact between a pair of teeth must always pass through the pitch point.
4. Explain the terms : (i) Module, (ii) Pressure angle, and (iii) Addendum.
5. Explain the different classifications of followers.
6. Define the following terms as applied to cam with a neat sketch :-(a) Base circle, (b) Pitch circle, (c) Pressure angle
7. Why reciprocating masses is cannot be completely balanced by revolving mass?
8. Derive the formula for the magnitude of gyroscopic couple.
9. Write down the differences between a gyroscope and a flywheel.
10. Explain the term hunting and isochronism.

PART – B

(*ANSWER ONE FULL QUESTION FROM EACH MODULE*)

MODULE – 1

11. The dimensions and configuration of the four bar mechanism, shown in Figure, are as follows : P_1A = 300 mm; P_2B = 360 mm; AB = 360 mm, and P_1P_2 = 600 mm. The angle AP_1P_2 = 60°. The crank P_1A has an angular velocity of 10 rad/s and an angular acceleration of 30 rad/s2, both clockwise. Determine the angular velocities and angular accelerations of P_2B, and AB and the velocity and acceleration of the joint B. (14 marks)



OR

12. a) With neat sketches explain the inversions of a four bar mechanism. (7 marks)

b) Derive the equation for the corrioli's component of acceleration. (7 marks)

MODULE – 2

13. An internal wheel B with 80 teeth is keyed to a shaft F. A fixed internal wheel C with 82 teeth is concentric with B. A compound wheel D-E gears with the two internal wheels; D has 28 teeth and gears with C while E gears with B. The compound wheels revolve freely on a pin which projects from a disc keyed to a shaft A co-axial with F. If the wheels have the same pitch and the shaft A makes 800 r.p.m., what is the speed of the shaft F ? Sketch the arrangement.

(14 marks)

OR

14. a) What do you mean by a self-energizing brake and self-locking brake. (4 Marks)

b) A simple band brake operates on a drum of diameter 600 mm that is running at a speed of 200 rpm. The coefficient of friction is 0.3. The brake band has an angle of contact of 270^o. One end of it is fastened to a fixed pin and the other end to the brake arm 125 mm and is placed perpendicular to the line bisecting the angle of contact.

i. What is the effort necessary at the end of brake arm to stop the wheel if 30 kW power is absorbed? What is the direction of rotation of drum for minimum pull?

ii. What is the width of steel band required for this brake if the maximum tensile stress is not to exceed 50 N/mm^2 and the thickness of band is 2.5 mm.

(10 marks)

MODULE – 3

15. A cam rotating clockwise at a uniform speed of 1000 r.p.m. is required to give a roller follower the motion defined below : 1. Follower to move outwards through 50 mm during 120° of cam rotation, 2. Follower to dwell for next 60° of cam rotation, 3. Follower to return to its starting position during next 90° of cam rotation, 4. Follower to dwell for the rest of the cam rotation. The minimum radius of the cam is 50 mm and the diameter of roller is 10 mm. The line of stroke of the follower is off-set by 20 mm from the axis of the cam shaft. If the displacement of the follower takes place with uniform and equal acceleration and retardation on both the outward and return strokes, draw profile of the cam. (14 marks)

OR

16. From the following data, draw the profile of a cam in which the follower moves with simple harmonic motion during ascent while it moves with uniformly accelerated motion during descent : Least radius of cam = 50 mm ; Angle of ascent = 48° ; Angle of dwell between ascent and descent = 42° ; Angle of descent = 60° ; Lift of follower = 40 mm ; Diameter of roller = 30 mm ; Distance between the line of action of follower and the axis of cam = 20 mm. If the cam rotates at 360 r.p.m. anticlockwise, find the maximum velocity and acceleration of the follower during descent. (14 marks)

MODULE – 4

17. a) A shaft carries four masses A, B, C and D of magnitude 200 kg, 300 kg, 400 kg and 200 kg respectively and revolving at radii 80 mm, 70 mm, 60 mm and 80 mm in planes measured from A at 300 mm, 400 mm and 700 mm. The angles between the cranks measured anticlockwise are A to B 45°, B to C 70° and C to D 120°. The balancing masses are to be placed in planes X and Y. The distance between the planes A and X is 100 mm, between X and Y is 400 mm and between Y and D is 200 mm. If the balancing masses revolve at a radius of 100 mm, find their magnitudes and angular positions. (10 marks)

    b) Explain the term swaying couple and hammer blow (4 marks)

OR

18. A ship propelled by a turbine rotor which has a mass of 5000 kg and a speed of 2100 r.p.m. The rotor has a radius of gyration of 0.5 m and rotates in a clockwise direction when viewed from the stern. Find the gyroscopic effects in the following conditions: 1. The ship sails at a speed of 30 km/h and steers to the left in a curve having 60 m radius. 2. The ship pitches 6 degree above and 6 degree below the horizontal position. The bow is descending with its maximum velocity. The motion due to pitching is simple harmonic and the periodic time is 20 seconds. 3. The ship rolls and at a certain instant it has an angular velocity of 0.03 rad/s clockwise when viewed from stern. Determine also the maximum angular acceleration during pitching. Explain how the direction of motion due to gyroscopic effect is determined in each case.

    (14 marks)

MODULE – 5

19. a) A Porter governor has all four arms 250 mm long. The upper arms are attached on the axis of rotation and the lower arms are attached to the sleeve at a distance of 30 mm from the axis. The mass of each ball is 5 kg and the sleeve has a mass of 50 kg. The extreme radii of rotation are 150 mm and 200 mm. Determine the range of speed of the governor. (10 marks)

    b) What is stability of a governor? How does it differ from sensitiveness? (4marks)

OR

20. A three cylinder single acting engine has its cranks set equally at 120° and it runs at 600 r.p.m. The torque-crank angle diagram for each cycle is a triangle for the power stroke with a maximum torque of 90 N-m at 60° from dead centre of corresponding crank. The torque on the return stroke is sensibly zero. Determine : 1. power developed. 2. coefficient of fluctuation of speed, if the mass of the flywheel is 12 kg and has a radius of gyration of 80 mm, 3. coefficient of fluctuation of energy, and 4. maximum angular acceleration of the flywheel. (14 marks)

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
MET284	THERMODYNAMICS	VAC	3	1	-	4

Preamble:

Thermodynamics is the study of energy. Without energy life cannot exist. Activities from breathing to the launching of rockets involves energy transactions and are subject to thermodynamic analysis. Engineering devices like engines, turbines, refrigeration and air conditioning systems, propulsion systems etc., work on energy transformations and must be analysed using principles of thermodynamics. So, a thorough knowledge of thermodynamic concepts is essential for a mechanical engineer. This course offers an introduction to the basic concepts and laws of thermodynamics.

Prerequisite: NIL

Course Outcomes:

After completion of the course the student will be able to

CO1	Understand basic concepts and laws of thermodynamics
CO2	Conduct first law analysis of open and closed systems
CO3	Determine entropy changes associated with different processes
CO4	Understand the application and limitations of the ideal gas equation of state
CO5	Determine change in properties of pure substances during phase change processes
CO6	Evaluate properties of ideal gas mixtures

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2										2
CO2	2	2	1	1								1
CO3	3	3	2	2								1
CO4	2	2	2	2								1
CO5	3	3	2	1								1
CO6	3	3	2	2								1

Assessment Pattern

Blooms Category	CA			ESA
	Assignment	Test - 1	Test - 2	
Remember	25	20	20	10
Understand	25	40	40	20
Apply	25	40	40	70
Analyse	25			
Evaluate				
Create				

Continuous Internal Evaluation Pattern:

Attendance : 10 marks

Continuous Assessment Test (2 numbers) : 25 marks

Assignment/Quiz/Course project : 15 marks

Mark distribution & Duration of Examination :

Total Marks	CA	ESE	ESE Duration
150	50	100	3 Hours

End semester pattern:

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

COURSE LEVEL ASSESSMENT QUESTIONS

Course Outcome 1

1. Discuss the limitations of first law of thermodynamics.

2. Second law of thermodynamics is often called a directional law . Why?

3. Explain Joule-Kelvin effect. What is the significance of the inversion curve ?

Course Outcome 2

1. A mass of 2.4 kg of air at 150 kPa and 12°C is contained in a gas – tight, frictionless piston – cylinder device. The air is now compressed to a final pressure of 600 kPa . During this process, heat is transferred from the air such that the temperature inside the cylinder remains constant. Calculate the work input during this process.

2. Carbon dioxide enters an adiabatic nozzle steadily at 1 MPa and 500°C with a mass flow rate of 600 kg/hr and leaves at 100 kPa and 450 m/s. The inlet area of the nozzle is 40 cm^2. Determine (a) the inlet velocity and (b) the exit temperature

3. Water is being heated in a closed pan on top of a range while being stirred by a paddle – wheel. During the process, 30 kJ of heat is transferred to the water and 5 kJ of heat is lost to the surrounding air. The paddle – wheel work amounts to 500 N-m. Determine the final energy of the system, if its initial energy is 10 kJ.

Course Outcome 3

1. An adiabatic vessel contains 2 kg of water at 25˚C. B paddle – wheel work transfer, the temperature of water is increased to 30˚C. If the specific heat of water is assumed to be constant at 4.186 kJ/kg.K, find the entropy change of the universe.

2. Two kilograms of water at 80°C is mixed adiabatically with 3 kg of water at 30°C in a constant pressure process at 1 atm. Find the increase in entropy of the total mass of water due to the mixing process.

3. An iron block of unknown mass at 85^{o}C is dropped into an insulated tank that contains 0.1 m3 of water at 20^{o}C. At the same time a paddle-wheel driven by a 200 W motor is activated to stir the water. Thermal equilibrium is established after 20 minutes when the final temperature is 24^{o}C. Determine the mass of the iron block and the entropy generated during this process.

Course Outcome 4

1. Discuss the limitations of ideal gas equation.

2. Discuss law of corresponding states and its role in the construction of compressibility chart.

3. A rigid tank contains 2 kmol of N_2 and 6 kmol of CH_4 gases at 200 K and 12 MPa. Estimate the volume of the tank, using (a) ideal gas equation of state (b) the compressibility chart and Amagat's law

Course Outcome 5

1. Steam is throttled from 3 MPa and 600˚C to 2.5 MPa. Determine the temperature of the steam at the end of the throttling process.

2. Determine the change in specific volume, specific enthalpy and quality of steam as saturated steam at 15 bar expands isentropically to 1 bar. Use steam tables

3. Estimate the enthalpy of vapourization of steam at 500 kPa, using the Clapeyron equation and compare it with the tabulated value

Course Outcome 6

1. A gaseous mixture contains , by volume, 21%nitrogen, 50% hydrogen and 29 % carbon dioxide. Calculate the molecular weight of the mixture, the characteristic gas constant of the mixture and the value of the reversible adiabatic expansion index - γ. At 10˚C, the C_p values of nitrogen, hydrogen and carbon dioxide are 1.039, 14.235 and 0.828 kJ/kg.K respectively.

2. A mixture of 2 kmol of CO_2 and 3 kmol of air is contained in a tank at 199 kPa and 20˚C. Treating air to be a mixture of 79% N_2 and 21% O_2 by volume , calculate (a) the individual mass of CO_2 , N_2 and O_2, (b) the percentage content of carbon by mass in the mixture and (c) the molar mass , characteristic gas constant and the specific volume of the mixture

3. A gas mixture in an engine cylinder has 12% CO_2, 11.5 % O_2 and 76.5% N_2 by volume. The mixture at 1000˚C expands reversibly, according to the law $PV^{1.25}$ = constant, to 7 times its initial volume. Determine the work transfer and heat transfer per unit mass of the mixture.

SYLLABUS

Module 1: Role of Thermodynamics and it's applications in Engineering and Science –Basic Concepts Macroscopic and Microscopic viewpoints, Concept of Continuum, Thermodynamic System and Control Volume, Surrounding, Boundaries, Types of Systems, Universe, Thermodynamic properties, Process, Cycle, Thermodynamic Equilibrium, Quasi – static Process, State, Point and Path function. Zeroth Law of Thermodynamics, Measurement of Temperature, reference Points, Temperature Scales.

Module 2: Energy - Work - Pdv work and other types of work transfer, free expansion work, heat and heat capacity. Joule's Experiment- First law of Thermodynamics - First law applied to Non flow Process- Enthalpy- specific heats- PMM1, First law applied to Flow Process, Mass and Energy balance in simple steady flow process. Applications of SFEE, Limitations of the First Law.

Module 3: Second Law of Thermodynamics, Thermal Reservoir, Heat Engine, Heat pump – Kelvin-Planck and Clausius Statements, Equivalence of two statements, Reversibility, Irreversible Process, Causes of Irreversibility, PMM2, Carnot's theorem and its corollaries, Absolute Thermodynamic Temperature scale. Clausius Inequality, Entropy- Entropy changes in various thermodynamic processes, principle of increase of entropy and its applications, Entropy generation, Entropy and Disorder, Reversible adiabatic process- isentropic process, Third law of thermodynamics.

Module 4: Pure Substances, Phase Transformations, Triple point, properties during change of phase, T-v, p-v and p-T diagram of pure substance, p-v-T surface, Saturation pressure and Temperature, T-h and T-s diagrams, h-s diagrams or Mollier Charts, Dryness Fraction, steam tables. Property calculations using steam tables. The ideal Gas Equation, Characteristic and Universal Gas constants, Limitations of ideal Gas Model: Equation of state of real substances, Compressibility factor, Law of corresponding state, Compressibility charts.

Module 5: Mixtures of ideal Gases – Mole Fraction, Mass fraction, Gravimetric and volumetric Analysis, Dalton's Law of partial pressure, Amagat's Laws of additive volumes, Gibbs-Dalton's law Equivalent Gas constant and Molecular Weight, Properties of gas mixtures: Internal Energy, Enthalpy, specific heats and Entropy. General Thermodynamic Relations – Combined First and Second law equations – Helmholtz and Gibb's functions - Maxwell's Relations, Tds Equations. The Clapeyron Equation, equations for internal energy, enthalpy and entropy, specific heats, Throttling process, Joule Thomson Coefficient, inversion curve.

Text Books

1. P. K. Nag, Engineering Thermodynamics, McGraw Hill, 2013

2. E. Rathakrishnan Fundamentals of Engineering Thermodynamics, PHI, 2005

3. Y. A. Cengel and M. A. Boles, Thermodynamics an Engineering Approach, McGraw Hill, 2011

Reference Books:

1. Moran J., Shapiro N. M., Fundamentals of Engineering Thermodynamics, Wiley, 2006

2. R. E. Sonntag and C. Borgnakke, Fundamentals of Thermodynamics, Wiley, 2009

3. Holman J. P. Thermodynamics, McGraw Hill, 2004

4. M. Achuthan, Engineering Thermodynamics, PHI, 2004

COURSE PLAN

Module	Topics	Hours Allotted
1	Role of Thermodynamics and it's applications in Engineering and Science – Basic Concepts Macroscopic and Microscopic viewpoints, Concept of Continuum, Thermodynamic System and Control Volume, Surrounding, Boundaries, Types of Systems, Universe	2L
	Thermodynamic properties, Process, Cycle, Thermodynamic Equilibrium, Quasi – static Process, State, Point and Path function.	2L
	Zeroth Law of Thermodynamics, Measurement of Temperature, reference Points, Temperature Scales.	2L + 1T
2	Energy - Work - Pdv work and other types of work transfer, free expansion work, heat and heat capacity.	2L + 1T
	Joule's Experiment- First law of Thermodynamics - First law applied to Non flow Process- Enthalpy- specific heats- PMM1	2L + 1T
	First law applied to Flow Process, Mass and Energy balance in simple steady flow process. Applications of SFEE, Limitations of first law	2L + 1T
3	Second Law of Thermodynamics, Thermal Reservoir, Heat Engine, Heat pump – Kelvin-Planck and Clausius Statements, Equivalence of two statements	3L
	Reversibility, Irreversible Process, Causes of Irreversibility, PMM2, Carnot's theorem and its corollaries, Absolute Thermodynamic Temperature scale.	2L + 1T
	Clausius Inequality, Entropy- Entropy changes in various thermodynamic processes, principle of increase of entropy and its applications, Entropy generation, Entropy and Disorder, Reversible adiabatic process- isentropic process, Third law of thermodynamics	2L + 2T
4	Pure Substances, Phase Transformations, Triple point, properties during change of phase, T-v, p-v and p-T diagram of pure substance, p-v-T surface,	3L
	Saturation pressure and Temperature, T-h and T-s diagrams, h-s diagrams or Mollier Charts, Dryness Fraction, steam tables. Property calculations using steam tables	2L + 1T

	The ideal Gas Equation, Characteristic and Universal Gas constants, Limitations of ideal Gas Model: Equation of state of real substances, Compressibility factor, Law of corresponding state, Compressibility charts.	2L +1T
5	Mixtures of ideal Gases – Mole Fraction, Mass fraction, Gravimetric and volumetric Analysis, Dalton's Law of partial pressure, Amagat's Laws of additive volumes, Gibbs-Dalton's law.	2L
	Equivalent Gas constant and Molecular Weight, Properties of gas mixtures: Internal Energy, Enthalpy, specific heats and Entropy	2L +1T
	General Thermodynamic Relations – Combined First and Second law equations – Helmholtz and Gibb's functions - Maxwell's Relations	2L
	Tds Equations. The Clapeyron Equation, equations for internal energy, enthalpy and entropy, specific heats, Throttling process, Joule Thomson Coefficient, inversion curve.	2L + 1T

MODEL QUESTION PAPER

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

THIRD SEMESTER B.TECH DEGREE EXAMINATION

Course Code : MET284

Course Name : THERMODYNAMICS

(Permitted to use Steam Tables and Mollier Chart)

Max. Marks : 100 Duration : 3 Hours

Part – A

Answer all questions.

1. Define thermodynamics. List a few of its applications

2.Differentiate between intensive and extensive properties.

3. Differentiate between heat and work.

4. Explain system approach and control volume approach as applied in the analysis of a flow process.

5. An inventor claims to have developed an engine that delivers 26 kJ of work using 82 kJ of heat while operating between temperatures 120°C and 30°C. Is his claim valid ? Give the reason for your answer.

6. Show that two reversible adiabatics cannot intersect

7.Define (i)critical point and (ii) triple point, with respect to water

8. Why do real gases deviate from ideal gas behaviour? When do they approach ideal behaviour?

9. Define Helmholtz function and Gibbs function and state their significance

10. State Dalton's law and Amagat's laws for ideal gas mixtures.

(3 x 10 = 30 marks)

Part – B

Answer any two full questions from each module.

Module - 1

11.a] Explain macroscopic and microscopic approach to thermodynamics . (7 marks)

b] With the aid of a suitable diagram, explain the working of constant volume gas thermometer. (7 marks)

OR

12.a] What is meant by thermodynamic equilibrium ? What are the essential conditions for a system to be in thermodynamic equilibrium ? (7 marks) b] Express the temperature of 91°C in (i) Farenhiet (ii) Kelvin (iii) Rankine. (7 marks)

Module – 2

13.a] A mass of 2.4 kg of air at 150 kPa and 12°C is contained in a gas – tight, frictionless piston – cylinder device. The air is now compressed to a final pressure of 600 kPa . During this process, heat is transferred from the air such that the temperature inside the cylinder remains constant. Calculate the work input during this process. (7 marks)

a] Air enters a 28 cm diameter pipe steadily at 200 kPa and 20°C with a velocity of 5m/s. Air is heated as it flows, and leaves the pipe at 180 kPa and 40°C. Determine (i) the volume flow rate of air at the inlet (ii) the mass flow rate of air and (iii) the velocity and volume flow rate at the exit. (7 marks)

OR

14.a] A turbine operates under steady flow conditions, receiving steam at the following conditions : pressure 1.2 MPa, temperature 188°C, enthalpy 2785 kJ/kg, velocity 33.3 m/s and elevation 3m. The steam leaves the turbine at the following conditions : pressure 20 kPa, enthalpy 25kJ/kg, velocity 100 m/s, and elevation 0 m. Heat is lost to the surroundings at the rate of 0.29 kJ/s. If the rate of steam flow through the turbine is 0.42 kg/s, what is the power output of the turbine in kW ? (7 marks)

b] Derive the steady flow energy equation, stating all assumptions. (7 marks)

Module – 3

15.a]State the Kelvin-Planck and Clausius statements of the second law of thermodynamics and prove their equivalence. (7 marks)

b]A heat engine operating between two reservoirs at 1000 K and 300 K is used to drive a heat pump which extracts heat from the reservoir at 300 K at a rate twice that at which the engine rejects heat to it. If the efficiency of the engine is 40 % of the maximum possible and the COP of the heat pump is 50 % of the maximum possible, what is the temperature of the reservoir to which the heat pump rejects heat ? What is the rate of heat rejection from the heat pump, if the rate of heat supply to the engine is 50kW ? (7 marks)

OR

16.a] A house is to be maintained at 21°C during winter and at 26°C during summer. Heat leakage through the walls, windows and roof is about 3000 kJ/hr per degree temperature difference between the interior of the house and the environment. A reversible heat pump is proposed for realising the desired heating and cooling. What is the minimum power required to run the heat pump in the reverse, if the outside temperature during summer is 36°C? Also find the lowest environment temperature during winter for which the inside of the house can be maintained at 21°C consuming the same power. (8 marks)

b] Give the Nernst statement of the third law and explain its significance. (6 marks)

Module – 4

17.a]Show the constant pressure transformation of unit mass of ice at atmospheric pressure and -20°C to superheated steam at 220°C on P-v , T-v and P-T coordinate systems and explain their salient features . (8 marks)

b] Nitrogen enclosed in a piston cylinder arrangement is at a pressure of 2 bar and temperature 75°C. Calculate the specific volume of Nitrogen using ideal gas equation. What would be the specific volume of this Nitrogen , if its compressibility factor at the prevailing condition is 0.9.
. (6 marks)

OR

18.a]Steam at 25 bar and 300°C expands isentropically to 5 bar. Calculate the change in enthalpy, volume and temperature of unit mass of steam during this process using steam tables and Mollier chart and compare the values (8 marks)

b]Explain law of corresponding states and its significance to the generalized compressibility chart. (6 marks)

Module – 5

19.a] Derive the expressions for the equivalent molecular weight and characteristic gas constant for a mixture of ideal gases. (6 marks)

b] 0.5 kg of Helium and 0.5 kg of Nitrogen are mixed at 20°C and at a total pressure of 100 kPa. Find (i) volume of the mixture (ii) partial volumes of the components (iii) partial pressures of the components (iv) the specific heats of the mixture and (v) the gas constant of the mixture. Take ratio of specific heats for Helium and Nitrogen to be 1.667 and 1.4 respectively. (8 marks)

OR

20.a] 2 kg of carbon dioxide at 38°C and 1.4 bar is mixed with 5 kg of nitrogen at 150°C and 1.03 bar to form a mixture at a final pressure of 70 kPa. The process occurs adiabatically in a steady flow apparatus. Calculate the final temperature of the mixture and the change in entropy during the mixing process. Take specific heat at constant pressure for CO_2 and N_2 as 0.85 kJ/kgK and 1.04 kJ/kg respectively. (7 marks)

b]Derive the Maxwell relations. Explain their significance? (7 marks)

MET 286	MANUFACTURING TECHNOLOGY (MINOR)	CATEGORY	L	T	P	Credits	Year of Introduction
		VAC	3	1	0	4	2019

Preamble:

1. To understand basic manufacturing processes of casting and welding
2. Provide a detailed discussion on the welding process and the physics of welding.
3. To understand mechanisms of material removal in LBM and EBM process
4. To introduce the different forming process of forging, extrusion and drawing.
5. To introduce the different fabrication of microelectronic devices

Prerequisite: MET 255 - Material Science & Technology (Minor)

Course Outcomes - At the end of the course students will be able to

CO 1	Illustrate the basic principles of foundry practices and special casting processes, their advantages, limitations and applications.
CO 2	Categorize welding processes according to welding principle and material.
CO 3	Understand the advantages of LBM and EBM over fusion welding process.
CO 4	An ability to understand the principles of the basic microelectronic processing technology.
CO 5	Learn about key aspects of the microelectronics industry, from device design, to processing, to photolithography, to manufacturing and packaging. Students will come out knowing the core processes of ion implantation, diffusion, oxidation, deposition, etching, including the fundamental physical mechanisms, and the necessary understanding for using these processes in a manufacturing environment.

Mapping of course outcomes with program outcomes (Minimum requirements)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	-	-	-	-	-	-	-	-		-	-
CO 2	-	-	-	-	-	-	-	-	-	-	-	2
CO 3	-	-	3	-	-	-	-	-	-	-	-	-
CO 4	-	-	-	3	-	-	-	-	-	-	-	-
CO 5	-	4	-	-	-	-	-	-	-	-	-	-

ASSESSMENT PATTERN

Bloom's taxonomy	Continuous Assessment Tests		End Semester Examination (Marks)
	Test I (Marks)	Test II (Marks)	
Remember	25	25	25
Understand	15	15	15
Apply	30	25	30
Analyze	10	10	10
Evaluate	10	15	10
Create	10	10	10

Mark distribution

Total Marks	CIE marks	ESE marks	ESE duration
150	50	100	3 Hours

Continuous Internal Evaluation (CIE) Pattern:

Attendance	10 marks
Regular class work/tutorials/assignments	15 marks
Continuous Assessment Test (2 numbers)	25 marks

End semester pattern:- There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1): - Illustrate the basic principles of foundry practices and special casting processes, their advantages, limitations and applications.

1. Explain Why casting is an important manufacturing processes
2. Name the important factors in selecting sand for molds.
3. Why does die casting produce the smallest cast parts?
4. What is the difference between sand-mold and shell mold casting?

Course Outcome 2 (CO2): Categorize welding processes according to welding principle and material.

1. Describe the functions and characteristics of electrodes. What functions do coatings have? How are electrodes classified?
2. Describe the role of filler metals in welding.
3. Explain the significance of the stiffness of the components being welded on both weld quality and part shape.

Course Outcome 3 (CO3): Understand the advantages of LBM and EBM over fusion welding process.

1. What is the power of LBM and EBM used for welding?
2. Why LBM and EBM are better quality than fusion welding?
3. What is the HAZ of LBM as compared to fusion welding process.

Course Outcome 4 (CO4): An ability to understand the principles of the basic microelectronic processing technology.

1. Why is silicon the semiconductor most used in IC technology?
2. Define selectivity and isotropy and their importance in relation to etching.
3. Explain the differences between wet and dry oxidation.
4. How is epitaxy different from other techniques used for deposition? Explain.

Course Outcome 5 (CO5): Learn about key aspects of the microelectronics industry, from device design, to processing, to photolithography, to manufacturing and packaging. Students will come out knowing the core processes of ion implantation, diffusion, oxidation, deposition, etching, including the fundamental physical mechanisms, and the necessary understanding for using these processes in a manufacturing environment.

1. Describe bulk and surface micromachining.
2. Lithography produces projected shapes, so true three dimensional shapes are more difficult to produce. What lithography processes are best able to produce three-dimensional shapes, such as lenses? Explain.
3. Explain how you would produce a spur gear if its thickness was one-tenth of its diameter and its diameter was (a) 10 um, (b) 100 um, (c) 1 mm, (d) 10 mm, and (e) 100 mm.

SYLLABUS

Module I

Metal casting:-sand casting:- shell molding, evaporative pattern casting, investment casting, permanent mold casting, vacuum casting, slush casting, pressure casting, die casting, centrifugal casting, squeeze casting, semi solid metal forming, casting for single crystal, casting defects.

Module II

Powder metallurgy:-powder production methods; powder characteristics; blending, mixing; compaction of metal powders; sintering fundamentals and mechanisms; infiltration and impregnation - Welding: arc welding: non consumable electrodes; heat affected zone; quality; case study and weld ability of metals.

Module III

Consumable electrodes; electron and laser beam welding; heat affected zone; power density; weld quality; case study; applications - Brazing:- filler metals, fluxes, joint strength; brazing methods, applications -Soldering:- solders and fluxes - soldering methods - solder ability, case study, typical joint designs, applications.

Module IV

Metal forging: quality, defects -Metal extrusion: process, defects, applications - Metal drawing process, drawing practice, defects, applications - Fabrication of microelectronic devices - crystal growing and wafer preparation - Film deposition - oxidation - Photo lithography

Module V

Different lithography methods - Etching, wet etching, dry etching- diffusion and Ion implantation- metallization and testing - wire bonding and packing - yield and reliability - fabrication of micro electro mechanical devices.

Text Books

1. Serope Kalpakjian, Steven R. Schmid - Manufacturing Engineering and Technology, seventh edition, Pearson.

Reference

1. https://nptel.ac.in/courses/103106075/
2. Principles of Metal Casting – Hine and Rosenthal
3. Materials and Processes in Manufacturing - Paul Degarma E and Ronald A. Kosher
4. Manufacturing Technology Foundry, Forming and Welding – P. N. Rao

MODEL QUESTION PAPER

MANUFACTURING PROCESS - MET 286 Max. Marks : 100 **Duration : 3 Hours**

Part – A

Answer all questions.

Answer all questions, each question carries 3 marks

1. What are composite molds? Why are they used?
2. What are the advantages of pressure casting over other processes?
3. Describe what occurs to metal powders during sintering.
4. Explain the basic principles of arc-welding processes.
5. Are fluxes necessary in brazing? If so, why?
6. Soldering is generally applied to thinner components. Explain Why.
7. Why is control of the volume of the blank important in closed-die forging?
8. Define selectivity and isotropy and their importance in relation to etching.
9. Describe the difference between isotropic etching and anisotropic etching.
10. What is the difference between chemically reactive ion etching and dry-plasma etching?

PART -B

Answer one full question from each module.

MODULE -1

11. Explain why squeeze casting produces parts with better mechanical properties, dimensional accuracy, and surface finish than do expendable-mold processes (14 marks).

OR

12. Explain different types of casting defeats in detail (14 marks).

MODULE -2

13. a.Explain the difference between impregnation and infiltration. Give some applications of each (7 marks).

    b.Describe the relative advantages and limitations of cold and hot isostatic pressing (7 marks).

OR

14. Explain the factors that contribute to the differences in properties across a welded joint (14 marks).

MODULE -3

15. a.What are the principles of (a) wave soldering and (b) reflow soldering? (7 marks).

    b.It is common practice to tin-plate electrical terminals to facilitate soldering. Why is it tin that is used? (7 marks).

OR

16. Examine various household products and describe how their components are joined and assembled. Explain why those particular processes were used and not others (14 marks).

MODULE -4

17. a.Describe the factors involved in precision forging (7 marks).

    b.Explain why cold extrusion is an important manufacturing process (7 marks).

OR

18. a.A common problem in ion implantation is channeling, in which the high-velocity ions travel deep into the material via channels along the crystallographic planes before finally being stopped. How could this effect be avoided? Explain (7 marks).

    b.Describe your understanding of the important features of clean rooms and how they are maintained (7 marks).

MODULE -5

19. a.List the advantages and disadvantages of surface micromachining compared with bulk micromachining (7 marks).

    b.What is the difference between chemically reactive ion etching and dry-plasma etching? (7 marks).

OR

20. a. What is the main limitation to successful application of MEMS? (7 marks).

    b. What is the purpose of a spacer layer in surface micromachining? (7 marks).

Course content and lecture schedules.

Module	TOPIC	No. of hours	Course outcomes
1.1	Metal casting:-sand casting:- sand, types of sand mold, pattern, cores, casting operations.	2	CO1
1.2	Shell molding, plaster and ceramic mold casting; evaporative pattern casting, investment casting,	3	CO1 CO5
1.3	Permanent mold casting, vacuum casting, slush casting, pressure casting, die casting,	2	

1.4	Centrifugal casting, squeeze casting, semi solid metal forming - applications of each process.	2	CO1
1.5	Casting for single crystal, applications of each process, casting defects.	1	
2.1	Powder metallurgy:-powder production methods, atomization, reduction, electrolytic deposition, carbonyls, comminution.	2	CO2
2.2	Powder characteristics:- particle size, shape and distribution	1	CO2 CO5
2.3	Blending, mixing and compaction of metal powders, isostatic pressing	2	CO2
2.4	Sintering: fundamentals and mechanisms - infiltration and impregnation.	1	
2.5	Welding: arc welding non consumable electrodes, heat transfer in arc welding, gas tungsten arc, plasma arc and atomic hydrogen welding; heat affected zone, weld ability, weld quality, applications of each processes.	3	CO4 CO5
3.1	Consumable electrodes:-shielded metal, submerged, gas metal arc welding, heat affected zone, weld ability, weld quality, applications of each processes.	3	CO4
3.3	Electron and laser beam welding, heat affected area, power density, weld quality, heat affected zone, case study, applications of each processes.	1	
3.4	Brazing:- filler metals, fluxes, joint strength; brazing methods, torch, furnace, induction, resistance, dip brazing, applications of each processes.	2	CO4
3.5	Soldering:-types of solders and fluxes - different soldering methods - solder ability, case study, typical joint designs, applications of each processes.	2	CO4
4.1	Metal forging:-open die, impression die, closed die, precision die, quality, defects.	3	CO4
4.2	Metal extrusion:-process, hot, cold, impact and hydrostatic extrusion; defects, applications - Metal drawing process- drawing practice- defects, applications of each processes.	3	
4.3	Fabrication of microelectronic devices:-clean rooms-semiconductors and silicon- crystal growing and wafer preparation	2	CO4
4.4	Film deposition - oxidation - Photo lithography	1	
5.1	electron beam lithography, X-ray, Ion beam, photo resistant lithography, scattering with angular limitations projection electron beam lithography.	1	CO4
5.2	Etching:- wet etching:- isotropic etchants, anisotropic etching - dry etching:-sputter, reactive plasma, physical chemical and cryogenic dry etching.	2	CO4
5.3	Diffusion and Ion implantation- metallization and testing- Wire bonding and packing-yield and reliability - printed circuit boards	3	CO4 CO5
5.4	Fabrication of micro electro-mechanical devices:-micromachining of MEMS devices: bulk and surface micro machining, single crystal silicon reactive etching and metallization, silicon micromachining by single step plasma etching, etching combined with diffusion bonding with suitable example and applications.	3	CO4

SEMESTER -4

HONOURS

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
MET292	CONTINUUM MECHANICS	VAC	3	1	0	4

Preamble:

At the end of the course the students will have a comprehensive, systematic and integrated knowledge of the principles of continuum mechanics. They be conversant with physical laws and analytical tools such as tensor calculus required to formulate and solve continuum problems. Also they have an in-depth understanding of the common principles which underlie the disciplines of solid mechanics and fluid mechanics – hitherto considered mostly separate. The course equip the students to pursue further specialized areas of study such as aeroelasticity, nonlinear mechanics, biomechanics etc. which are essentially based on continuum mechanics.

Prerequisite:

MECHANICS OF SOLIDS

Course Outcomes:

After the completion of the course the student will be able to

CO 1	**Make use of the concepts of tensor formalism for practical applications**
CO 2	**Apply deformation and strain concepts for practical situations**
CO 3	**Identify stresses acting on components subjected to complex loads**
CO 4	**Make use of fundamental laws for problem formulations and mathematical modeling**
CO 5	**Develop constitutive relations and solve 2 D elasticity problems**

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO 11	PO 12
CO 1	3				2				2			3
CO 2	3	3	3		2	1			2			3
CO 3	3	3	3		2	1			2			3
CO 4	3								2			3
CO 5	3	3	3		2	1			2			3

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	10
Understand	20	20	20
Apply	20	20	70
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

COURSE LEVEL ASSESSMENT QUESTIONS

Course Outcome 1

1. With the help of mathematical derivations obtain the relation between circulation of a vector field per unit area around a point in a plane and curl of the vector.
2. Prove the vector identity $u \times (v \times w) = (u.w)v - (u.v)w$
3. Show that a) $\delta_{3p} v_p = v_3$ b) $\delta_{3i} A_{ji} = A_{j3}$

Course Outcome 2

1. Discuss the physical interpretations of components of Linearized strain tensor.
2. Given the displacement components $u_1 = kx_2^2, u_2 = 0, u_3 = 0, k = 10^{-4}$, obtain infinitesimal strain tensor E
3. Given $x_1 = X_1 + 2X_2,\ x_2 = X_2, x_3 = X_3,$ obtain the right Cauchy Green deformation tensor, right stretch tensor and rotation tensor.

Course Outcome 3

1. Given a continuum, where the stress state is known at one point and is represented by the Cauchy stress tensor components $[\sigma_{ij}] = \begin{bmatrix} 1 & 1 & 0 \\ 1 & 1 & 0 \\ 0 & 0 & 2 \end{bmatrix}$ Pa, find the principal stresses and principal directions.
2. The stress state at one point is represented by the Cauchy stress components $[\sigma_{ij}] = \begin{bmatrix} \sigma & a\sigma & b\sigma \\ a\sigma & \sigma & c\sigma \\ b\sigma & c\sigma & \sigma \end{bmatrix}$, where a, b, c constants are and σ is the value of the stress. Determine the constants such that the traction vector on the octahedral plane is zero.
3. Find the maximum principal stress, maximum shear stress and their orientations for the state of stress given $[\sigma_{ij}] = \begin{bmatrix} 6 & 9 & 0 \\ 9 & -6 & 0 \\ 0 & 0 & 3 \end{bmatrix} MPa$

Course Outcome 4

1. Explain Reynold's Transport Theorem
2. Prove the symmetry of stress using principle of conservation of angular momentum.
3. Obtain the Eulerian form of continuity equation

Course Outcome 5

1. From linear elastic constitutive relation for isotropic materials, deduce the strain stress relation $\varepsilon_{ij} = \frac{1+\nu}{E}\sigma_{ij} - \frac{\nu}{E}\sigma_{kk}\delta_{ij}$
2. Formulate the stress compatibility equation for plain strain problems in the absence of body force.
3. Derive the stress compatibility equation for a plain stress problem with body force. State the condition under which it becomes the biharmonic equation.

MODEL QUESTION PAPER

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

IV SEMESTER B.TECH DEGREE EXAMINATION

Course Code : MET292

Course Name : CONTINUUM MECHANICS

PART A

Each question carries three marks

1. Differentiate between vector space and inner product space.
2. Prove div (**A** x **B**) = curl **A**.**B** – curl **B**.**A**, using indicial notation.
3. Differentiate between Lagrangian and Eulerian description of fluid motion.
4. The Lagrangian coordinate of a material particle is $(x(t),\ y(t),\ z(t))$. Obtain the mathematical expression for the component of acceleration along the direction of motion of the material particle.
5. Derive an equation for octahedral shear stress in terms of the stress invariants.
6. The Cauchy stress tensor at a point P is given $\sigma_{ij} = \begin{bmatrix} 5 & 6 & 7 \\ 6 & 8 & 9 \\ 7 & 9 & 2 \end{bmatrix}$ GPa. Obtain the deviatoric and volumetric parts of the tensor.
7. Deduce the equilibrium equations from linear momentum principle.
8. Express the local and global form of Reynold's Transport Theorem.
9. Write down the stress strain relations of a linear elastic isotropic material.
10. Write down the radial and tangential components of stress in terms of Airy's stress function.

PART B

Answer one full question from each module.

MODULE 1

11 a) Evaluate using indicial notation (8)

i. $\mathbf{u} \times (\mathbf{v} \times \mathbf{w})$

ii. $(\mathbf{u}\mathbf{v}) : (\mathbf{w}\mathbf{w})$

b) Expand using summation convention (6)

iii. $\rho\dot{v}_i = \rho b_i + \sigma_{ij,j}$

iv. $e'_i = Q_{mi} e_m$

OR

12 a) Prove that $[A \quad B \quad C][D \quad E \quad F] = \begin{vmatrix} A.D & A.E & A.F \\ B.D & B.E & B.F \\ C.D & C.E & C.F \end{vmatrix}$ from there show that

$$e_{ijk}e_{rst} = \begin{vmatrix} \delta_{ir} & \delta_{is} & \delta_{it} \\ \delta_{jr} & \delta_{js} & \delta_{jt} \\ \delta_{kr} & \delta_{ks} & \delta_{kt} \end{vmatrix}$$ (9)

b) Establish the identity $e_{ijk}e_{mnk} = \delta_{im}\delta_{jn} - \delta_{in}\delta_{jm}$ (5)

MODULE 2

13 a) Given the motion of a body $x_i = X_i + 0.2tX_2\delta_{1i}$, for a temperature field given by $\theta = 2x_1 + (x^2)^2$, find the material description of temperature and the rate of change of temperature of a particle at time t=0 , which was at the place (0,1,0). (8)

b) Derive compatibility equation (6)

OR

14 a) Given that $[F] = \begin{bmatrix} \sqrt{3} & 1 & 0 \\ 0 & 2 & 0 \\ 0 & 0 & 1 \end{bmatrix}$, determine the left and right stretch tensors. (14)

b) Explain infinitesimal deformation theory.

c) Obtain an expression for Linearized strain.

MODULE 3

15 a) The stress matrix in MPa when refereed to axes $Px_1x_2x_3$ is (14)

$$[\sigma_{ij}] = \begin{bmatrix} 3 & 10 & 0 \\ -10 & 0 & 30 \\ 0 & 30 & -27 \end{bmatrix}$$

Determine

i. the principal stresses
ii. principal planes
iii. maximum shear stress
iv. Octahedral normal and shear stress

OR

16 a) The principal stresses of stress at a point are σ_1, σ_2 and σ_3 with $\sigma_1 > \sigma_2 > \sigma_3$. Now derive equations of the direction cosines of a plane passing through this point, which is subjected to normal and shear stress σ_n and r_n respectively. (6)

b) For the stress state given

$$[\sigma_{iijj}] = \begin{bmatrix} 12 & 9 & 0 \\ 9 & -12 & 0 \\ 0 & 0 & 6 \end{bmatrix} MPa$$

where the Cartesian coordinate variables XX_{ii} are in meters and the unit of stress are MPa. Determine the principal stresses and principal directions of stress at the point $XX = e_1 + 2e_2 + 3e_3$. (8)

MODULE 4

17 a) Derive the differential form of conservation of energy. (4)

b) What is localization theorem? Write down its relevance in the derivation of differential equations. (6)

c) Derive the Cauchy's equation of motion using the conservation of linear momentum principle (4)

OR

18 a) Prove the symmetry of stress $\sigma_{iijj} = \sigma_{jjii}$ using principle of conservation of angular momentum. (8)

b) Obtain the Eulerian form of continuity equation. (6)

MODULE 5

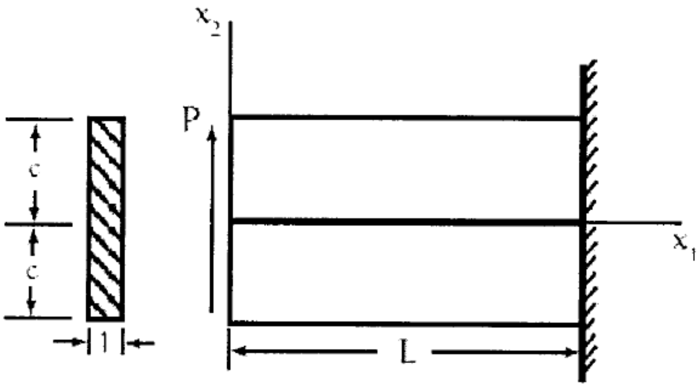
19 a)Show that for an isotropic elastic medium (6)

a. $\lambda = \frac{Evv}{(1+vv)(1-2vv)}$ b) $\mu = \frac{E}{2(1+vv)}$

b. Determine the radial stress and tangential stress developed in a thick cylinder of internal radius '*a*' and external radius '*b*' subjected internal pressure P_{ii} and external pressure P_o using stress function method. (8)

OR

20 Consider a special stress function having the form $\phi\phi = B_2x_1x_2 + D_4x_1x_3$. Show that this stress function ma)'- be adapted to solve for the stresses in an end-loaded cantilever beam as shown in the sketch. Assume the body forces are zero for this problem. (14)



SYLLABUS

Module 1

Mathematical preliminaries - Index notation, Einstein's summation convention- Kronecker delta and Levi-Civita symbols, Cartesian basis- Concept of tensor- Tensor as a linear transformation - Vector as a first order tensor- Coordinate transformation of vectors and tensors.

Principal values, trace and invariants-Gradient, divergence and curl of vector and tensor fields- Vector identities-Gauss' divergence and Stokes' theorems.

Module 2

Concept of continua- Reference and current configuration- Deformation gradient tensor- Lagrangian and Eulerian description of motion.

Polar decomposition theorem- Right and left Cauchy Green tensors- Infinitesimal deformation theory- Linearized strain- Principal strains- Saint Venant's compatibility equations

Module 3

Traction- Cauchy stress tensor- Stress component along orthonormal basis vector- Components of Cauchy stress tensor on any plane.

Principal planes- Principal stress components- Normal and shear stresses- Stress transformation- Equilibrium equations

Module 4

Balance Laws - Reynold's transportation theorem- Localization theorem- Lagrangian and Eulerian forms of equation for mass balance.

Balance of linear momentum equation- Balance of angular momentum- Symmetry of stress tensor- Balance of energy

Module 5

Constitutive relations - Generalized Hooke's law for isotropic materials in indicial and matrix forms- Relation connecting Lame's constants with Young's modulus, Poisson's ratio and Bulk modulus.

2D formulation of field equations; Airy's stress function- Biharmonic equation-Uni axial tension and pure bending of a beam; End loaded cantilever- Polar coordinates- Axisymmetric formulation- Lame's thick cylinder problem- Quarter circle cantilevered beam with radial load.

Text Books

1. G. Thomas Mase, George E. Mase.. Ronald E. Smelser. Continuum mechanics for engineers 3rd ed CRC Press
2. . Lawrence E. Malvern. Introduction to the Mechanics of a Continuous Medium – Prentice Hall

Reference Books

1. J.H. Heinbockel, Introduction to Tensor Calculus and Continuum Mechanics – Open Source
2. W. Michael Lai, David Ribin, Erhard Kaempl, Introduction to Continuum Mechanics 4th Ed., Butterworth- Heinemann
3. J. N. Reddy, An Introduction to Continuum Mechanics with applications - Cambridge University Press
4. Y. C. Fung, A First Course in Continuum Mechanics for Physical and Biological Engineers and scientists - Prentice Hall
5. Han-Chin W, Continuum mechanics and plasticity - CRC Press
6. Sudhakar Nair, Introduction to Continuum Mechanics – Cambridge University press
7. Morton E. Gurtin, An introduction to continuum mechanics, Academic Press
8. S.P. Timoshenko, J.N. Goodier, Theory of Elasticity, 3rd Edition, McGraw Hill Publishing

COURSE CONTENTS AND LECTURE SCHEDULE

Sl. No.	Topic	Number of lecture hours
1	Index notation, Einstein's summation convention- Kronecker delta and Levi-Civita symbols	2
2	Cartesian basis- Concept of tensor- Tensor as a linear transformation - Vector as a first order tensor	1
3	Coordinate transformation of vectors and tensors.	2
4	Principal values, trace and invariants	2
5	Gradient, divergence and curl of vector and tensor fields	2
6	Vector identities-Gauss' divergence and Stokes' theorems.	1
7	Concept of continua- Reference and current configuration, Lagrangian and Eulerian description of motion	2
8	Deformation gradient tensor, Right and left Cauchy Green tensors	2

9	Infinitesimal deformation theory- Linearized strain	2
10	Principal strains	1
11	Polar decomposition theorem	1
12	Saint Venant's compatibility equations	1
13	Traction- Cauchy stress tensor- Stress component along orthonormal basis vector	2
14	Components of Cauchy stress tensor on any plane., Normal and shear stresses	2
15	Principal planes- Principal stress components	2
16	Stress transformation	2
17	Reynold's transportation theorem- Localization theorem, Introduction on Balance Laws	1
18	Lagrangian and Eulerian forms of equation for mass balance.	1
19	Balance of linear momentum, equilibrium equations	1
20	Balance of angular momentum, Symmetry of stress tensor	1
21	Balance of energy	1
22	Constitutive relations - Generalized Hooke's law for isotropic materials in indicial and matrix forms	1
23	Relation connecting Lame's constants with Young's modulus, Poisson's ratio and Bulk modulus.	1
24	2D formulation of field equations; Airy's stress function; Biharmonic equation	4
25	Uni axial tension and pure bending of a beam; End loaded cantilever	1
26	Polar coordinates; Axisymmetric formulation	2
27	Lame's thick cylinder problem	2
28	Quarter circle cantilevered beam with radial load.	2

CODE MET294	COURSE NAME ADVANCED MECHANICS OF FLUIDS	CATEGORY	L	T	P	CREDIT
		VAC	3	1	0	4

Preamble:

This course is a survey of principal concepts and methods of fluid dynamics. Topics include conservation equations, exact solutions of Navier-Stokes Equations, potential flow solutions, Boundary layers; introduction to turbulence and turbulence modelling

Prerequisite:

MET 203- Mechanics of Fluids

Course Outcomes: After the completion of the course the student will be able to

CO 1	Apply conservation equations of fluid mechanics
CO 2	Use potential flow theory in fluid problems
CO 3	Utilize approximate solutions of the Navier-Stokes equations
CO 4	Compute effect on boundary layers.
CO 5	Explain turbulence and turbulence modelling

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3											
CO 2	3	2	1									
CO 3	3	2	1	1								
CO 4	3	2	1									
CO 5	3	1										

Assessment Pattern

Blooms Category	CA			ESA
	Assignment	Test - 1	Test - 2	
Remember	25	20	20	10
Understand	25	40	40	20
Apply	25	40	40	70
Analyse	25			
Evaluate				
Create				

Continuous Internal Evaluation Pattern:

Attendance : 10 marks

Continuous Assessment Test (2 numbers) : 25 marks

Assignment/Quiz/Course project : 15 marks

Mark distribution & Duration of Examination :

Total Marks	CA	ESE	ESE Duration
150	50	100	3 Hours

End semester pattern:

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

COURSE LEVEL ASSESSMENT QUESTIONS

Course Outcome 1

1. What is the significance of RTT in the study of transport phenomena.
2. Explain the relationship between the stress tensor and the rate of deformation.
3. Derive the expression for the Navier-Stokes equation and explain the different terms involved.

Course Outcome 2

1. Derive the expression for stream function and potential function of a doublet using the potential flow theory.
2. Derive the expression for lift for flow past a cylinder with circulation.
3. What is the significance of conformal mapping?

Course Outcome 3

1. Derive the expression for the pressure gradient for Couette flow.
2. Explain the working of a Viscometer based on the flow through a rotating annulus.
3. What is Stokes' first problem?

Course Outcome 4

1. Explain the development of boundary layer along a thin flat plate held parallel to a uniform flow. Point out the salient features.
2. Discuss on the effect of pressure gradient on boundary layer separation.
3. Find the thickness of the boundary layer at the trailing edge of a smooth plate of length 5 m and width 1.2 m when the plate is moving at 5 m/s in stationary air. Take the kinematic viscosity of air as 0.11 stokes.

Course Outcome 5

1. What are the semi-empirical theories associated with turbulent flow?
2. Explain the two equation models used in turbulent flow.
3. Distinguish between DNS and LES.

Syllabus

Module 1: Concept of viscosity, stress tensor, relation between stress and rate of deformation, Stokes hypothesis, Reynolds Transport Theorem, Mass, Momentum and Energy conservation, Derivation of Navier-Stokes equations.

Module 2: Potential flow: Uniform flow, source flow, sink flow, free vortex flow and super imposed flow-source and sink pair, doublet, plane source in a uniform flow(flow past a half body), source and sink pair in a uniform flow(flow past a Rankine oval body), doublet in a uniform flow(flow past a circular cylinder). Pressure distribution on the surface of the cylinder. Flow past a cylinder with circulation, Kutta-Juokowsky's law. Complex flow potential, complex flow potentials for source, sink, vortex and doublet. Potential flow between two parallel plates, potential flow in a sector. Introduction to conformal transformation, conformal mapping.

Module 3: Exact Solutions of Navier Stokes Equations. Parallel flow through straight channel and couette flow. Couette flow for negative, zero and positive pressure gradients, flow in a rotating annulus, Viscometer based on rotating annulus. Flow at a wall suddenly set to motion (Stokes first problem)

Module 4: Boundary layer equations; Boundary layer on a flat plate, Prandtl boundary layer equations, Blasius solution for flow over a flat plate, Von- Karman momentum integral equations, Pohlhausen approximation solution of boundary layer for non-zero pressure gradient flow, favorable and adverse pressure gradients, flow separation and vortex shedding. Boundary layer control.

Module 5: Introduction Statistical approach to turbulent flows, Length and time scales and Kolomogrov's energy cascading theory Reynolds averaged Navier Stokes equations, Turbulence modeling. Concept of eddy viscosity and Prandtl's mixing length hypothesis Zero, one and two equation turbulence models and Reynold's stress models. Concepts of LES and DNS.

Text Books

(1) White, F. M. *Viscous Fluid Flow*, McGraw Hill Education; 3 edition, 2017
(2) Schlichting, H. Boundary layer theory. McGraw Hill Education; 7 edition, 2014

COURSE PLAN

Module	Topics	Hours Allotted
I	Concept of viscosity, stress tensor, relation between stress and rate of deformation, Stokes hypothesis, Reynolds Transport Theorem, Mass, Momentum and Energy conservation, Derivation of Navier-Stokes equations.	6-2-0
II	Potential flow: Uniform flow, source flow, sink flow, free vortex flow and super imposed flow-source and sink pair, doublet, plane source in a uniform flow(flow past a half body), source and sink pair in a uniform flow(flow past a Rankine oval body), doublet in a uniform flow(flow past a circular cylinder). Pressure distribution on the surface of the cylinder. Flow past a cylinder with circulation, Kutta-Juokowsky's law. Complex flow potential, complex flow potentials for source, sink, vortex and doublet. Potential flow between two parallel plates, potential flow in a sector. Introduction to conformal transformation, conformal mapping.	7-2-0
III	Exact Solutions of Navier Stokes Equations. Parallel flow through straight channel and couette flow. Couette flow for negative, zero and positive pressure gradients, flow in a rotating annulus, Viscometer based on rotating annulus. Flow at a wall suddenly set to motion (Stokes first problem)	6-2-0
IV	Boundary layer equations; Boundary layer on a flat plate, Prandtl boundary layer equations, Blasius solution for flow over a flat plate, Von- Karman momentum integral equations, Pohlhausen approximation solution of boundary layer for non-zero pressure gradient flow, favorable and adverse pressure gradients, flow separation and vortex shedding. Boundary layer control.	8-3-0
V	Introduction Statistical approach to turbulent flows, Length and time scales and Kolomogrov's energy cascading theory Reynolds averaged Navier Stokes equations, Turbulence modeling. Concept of eddy viscosity and Prandtl's mixing length hypothesis Zero, one and two equation turbulence models and Reynold's stress models. Concepts of LES and DNS.	7-2-0

MODEL QUESTION PAPER

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

IV SEMESTER B.TECH DEGREE EXAMINATION

MET294 ADVANCED MECHANICS OF FLUIDS

Mechanical Engineering

Maximum: 100 Marks Duration: 3 hours

PART A

Answer all questions, each question carries 3 marks

1. What is Stokes hypothesis?
2. What is the importance of RTT in the study of transport phenomena?
3. What are the different elementary flows used in potential flow theory?
4. Draw the stream-lines and potential lines for a doublet in a uniform flow and mark the different regions.
5. With a neat sketch explain the Stokes first problem.
6. Draw the velocity profile in Couette flow for negative, zero and positive pressure gradients.
7. With a neat sketch explain the different regions of boundary layer flow over a flat plat
8. What are the different methods employed in controlling the boundary layer separation?
9. Explain Prandtl's Mixing length theory.
10. What is the importance of Turbulence Modeling in fluid dynamics?

(10×3=30 Marks)

PART B

Answer one full question from each module

MODULE-I

11. (a) Derive Reynolds Transport Theorem. (7 Marks)

    (b) Derive the expression for the law of conservation of mass from RTT. (7 Marks)

12. (a) Derive Navier-Stokes equations in Cartesian coordinate system. (10 Marks)

    (b) Write the expanded form of Navier-Stokes equations in Cartesian coordinate system. (4 Marks)

MODULE-II

13. (a) Explain uniform flow with source and sink. Obtain an expression for stream and velocity potential function and show their approximate distribution. (7 Marks)

    (b) A uniform flow with a velocity of 2m/s is flowing over a source placed at the origin. The stagnation point occurs at $(-0.398, 0)$. Determine: (i) Strength of the source, (ii) Maximum width of Rankine half-body and (iii) Other principal dimensions of the Rankine half-body. (7 Marks)

14. (a) *A* uniform flow with a velocity of 3m/s is flowing over a plane source of strength $30m^2/s$. The uniform flow and source flow are in the same plane. A point *P* is situated in the flow field. The distance of the point *P* from the source is 0.5m and it is at an angle of 30° to the uniform flow. Determine: (i) stream function at point *P* (ii) resultant velocity of flow at *P* and (iii) location of stagnation point from the source.hfill (10 Marks)

    (b) Describe the following terms: i)Complex flow potential ii) Conformal mapping(4 Marks)

MODULE-III

15. (a) An oil of viscosity 18 poise flows between two horizontal fixed parallel plates which are kept 150mm apart. The maximum velocity of flow is 1.5m/s. Find:

    i. The pressure gradient
    ii. The shear stress at the two horizontal parallel plates
    iii. The discharge per unit width for laminar flow of oil.

    (7 Marks)

    (b) Explain the significance of Navier-Stokes equation in viscous fluid flow. Derive the expression for flow in a rotating annulus from the Navier-Stokes Equation. (7 Marks)

16. (a) Derive the expression for pressure gradient in the parallel flow through a straight channel. (7 Marks)

    (b) Explain the working of a Viscometer based on the flow through a rotating annulus. (7 Marks)

MODULE-IV

17. (a) Explain the essential features of Blasius method of solving laminar boundary layer equations for a flat plate. Derive an expression for boundary layer thickness from this solution. (7 Marks)

(b) For the velocity profile for laminar boundary layer flows given as

$$\frac{u}{U} = 2(y/\delta) - (y/\delta)^2$$

find an expression for boundary layer thickness (δ), shear stress (τ_0) and co-efficient of drag (C_D) in terms of Reynold number. (7 Marks)

18. (a) For the velocity profile in laminar boundary layer as,

$$\frac{u}{U} = \frac{3}{2}\left(\frac{y}{\delta}\right) - \frac{1}{2}\left(\frac{y}{\delta}\right)^3$$

find the thickness of the boundary layer and the shear stress 1.5 m from the leading edge of a plate. The plate is 2m long and 1.4m wide and is placed in water which is moving with a velocity of 200mm per second. Find the total drag force on the plate if μ for water = .01 poise. (7 Marks)

(b) Derive Von Karman momentum integral equation for boundary layer flows.(7 Marks)

MODULE-V

19. (a) Explain and differentiate DNS and LES. (7 Marks)

(b) What is the difference between zero equation, one equation and two equation models in turbulent flow? (7 Marks)

20. (a) Explain in detail any one of the two equation models. (7 Marks)

(b) Explain Kolmogrovs energy cascade theory. (7 Marks)

MET 296	MATERIALS IN MANUFACTURING (HONORS)	CATEGORY	L	T	P	Credits	Year of Introduction
		VAC	3	1	0	4	2019

Preamble: Understanding of the correlation between the chemical bonds and crystal structure of metallic materials to their mechanical properties.

Recognize the importance of deformation of metals at high temperature.

Enrich knowledge of various behavior and property changes inside the material structure in raised temperature and methods to strengthening the material.

Provide in-depth proficiency in material science and engineering fields for elevated temperature applications.

Prerequisite: MET 202 - Metallurgy and Material Science

Course Outcomes - At the end of the course students will be able to

CO 1	Understand the chemical bonds, crystal structures and their relationship with the properties.
CO 2	Correlate structure and properties relationship for high temperature applications.
CO 3	Understand the attributes and purity obtainable through triple vacuum induction melting process.
CO 4	To have knowledge in improving material strength against high temperature environment and predict life time.
CO 5	Understand the properties of super alloys and its strengthening processes.

Mapping of course outcomes with program outcomes (Minimum requirements)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	-	3	-	-	-	-	-	-	-		-	-
CO 2	-	-	3	-	-	-	-	-	-	-	-	-
CO 3	-	-	-	3	-	-	-	-	-	-	-	-
CO 4	3	-	-	-	-	-	-	-	-	-	-	-
CO 5	-	-	-	-	-	-	-	-	-	-	-	3

ASSESSMENT PATTERN

Bloom's taxonomy	Continuous Assessment Tests		End Semester Examination (Marks)
	Test 1 (Marks)	Test 11 (Marks)	
Remember	25	25	25
Understand	15	15	15
Apply	30	25	30
Analyze	10	10	10
Evaluate	10	15	10
Create	10	10	10

Mark distribution

Total Marks	CIE marks	ESE marks	ESE duration
150	50	100	3 Hours

Continuous Internal Evaluation (CIE) Pattern:

Attendance	10 marks
Regular class work/tutorials/assignments	15 marks
Continuous Assessment Test (2 numbers)	25 marks

End semester pattern:- There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Part -A

Course Outcome 1 (CO1): Understand the chemical bonds, crystal structures and their relationship with the properties.

1. Why electrons of higher principal quantum number form weaker bonds.
2. Postulate why ionic and covalent bonded material exhibit bad conductors of heat and electricity?
3. What are the roles of surface imperfections on crack initiation.
4. Which mechanism of strengthening is the Hall- Petch equation related to?

Course Outcome 2 (CO2): Correlate structure and properties relationship for high temperature applications.

1. Nickel has an atomic weight of 58.71, a number which arises from the relative proportions of isotopes of weights 58, 60, 61, 62 and 64. Why is there little contribution from the isotopes of weight 59 and 63?
2. Comparison of the rates of interdiffusion of the transition group metals (the solutes) with nickel (the solvent) indicates that (i) the interdiffusion rate increases with increasing misfit strain between solvent and solute and (ii) the activation energy for interdiffusion decreases with increasing misfit strain. Why might these observations be contrary to expectation? How might this apparent anomaly be rationalised?

Course Outcome 3 (CO3): Understand the attributes and purity level obtainable through triple vacuum induction melting process.

1. What is the need of vacuum for obtaining purifying metals?
2. What are conditions for freckle formation and how can be eliminated?
3. Explain the need of electrode quality in ESR and VAR process?
4. Which are the factors governs the quality of vacuum arc remelting process.

Course Outcome 4 (CO4): To have knowledge in improving material strength against high temperature environment and predict life time.

1. Explain why it might not be sensible, even for single-crystal superalloys, to eliminate completely the grain-boundary strengtheners such as carbon and boron from the melt chemistry.
2. The rate of oxide formation in Al_2O_3 forming single-crystal superalloys is greatly increased with additions of Ti to the alloy chemistry. Explain why this effect occurs.
3. Non-conductive material will you recommend to use at high temperature explain?
4. Both titanium and steel melt at temperatures in excess of 1500 C. Steel can be used at temperatures as high as 1000C but titanium cannot. Why is this?

Course Outcome 5 (CO5): Understand the properties of super alloys and its strengthening processes.

1. The following defects can occur during the casting of single-crystal components:(i) high-angle grain boundaries, (ii) freckles and (iii) spurious grains. What is meant by these terms? Give a brief explanation of the origin of each effect.
2. Suggest a high electrical conductive material which can use at 1100C.
3. Give two reasons why the use of titanium alloys is increasing at the expense of aluminum in both civil and military aircraft.

SYLLABUS

MODULE - 1

Atomic structure- chemical bonds-crystallography-miller indices - slip - dislocation - crystallization-frank-reed source - Structural parameters in high-temperature deformed metals - dislocation structure - distances between dislocations in sub-boundaries - sub-boundaries as dislocation sources and obstacles -dislocations inside sub-grains - vacancy loops and helicoids - structural peculiarities of high - temperature deformation.

MODULE - II

Characteristics of high-temperature materials - The super alloys as high-temperature materials- The requirement: the gas turbine engine- Larson–Miller approach for the ranking of creep performance- development of the super alloys- Nickel as a high-temperature material: justification- super alloy production methods:- vacuum induction melting (VIM), vacuum arc remelting (VAR), VIM, electroslag remelting (ESR),VIM, ESR, VAR- Freckles, three rings, white spot- cleanliness.

MODULE - III

Superalloys:- metallurgy, characteristics - wrought, cast superalloys, properties -crystal structures, phases in superalloys, Iron-Nickel-base superalloys, Nickel-base superalloys, Cobalt-base superalloys, - elements causing brittle phase formation, detrimental tramp elements, elements producing oxidation and hot corrosion resistance- microstructure, gamma prime, gamma double prime, Carbide and Boride phases, strengthening mechanisms- Heat treatment.

MODULE - IV

Single-crystal super alloys for blade applications:- solidification, heat transfer, defects - mechanical behavior, performance in creep, fatigue -Titanium: binary phase diagram - production of ingot - forgings - shear bands - pickling - Ti alloys - machining and welding of Titanium - Heat Treatment - properties of titanium aluminides - Niobium: production of niobium - niobium in steel making – niobium alloys characteristics and applications- Niobium products for the superalloy industry.

MODULE - V

Molybdenum: Ferromolybdenum - production of molybdenum – properties - effect of molybdenum alloying– applications - TZM, TZC- Maraging steel:- reaction in austenite - austenite to martensite transformation- reaction in martensite - time of maraging - precipitate size - fracture toughness - welding and ageing attributes - superior features - applications - cobalt free maraging steel - intermetallics:- phase diagrams- Hume-Rothery phases- structures of $MgCu_2$, $MgZn_2$, $MgNi_2$.

Text Books

1. Callister William. D., Material Science and Engineering, John Wiley, 2014
2. Matthew J. Donachie, Stephen J. Donachie, Super alloys A Technical Guide, Second Edition, 2002 ASM International.

Reference

1. Barrett, C. S. and Massalski, T. B. Structure of metals, Third edition. New York, N.Y., McGraw-Hill Book Company, 1966.
2. Decker, Raymond Frank, Source book on maraging steels: A comprehensive collection of outstanding articles from the periodical and reference literature, Published by American Society for Metals (1979).
3. Gerd Lutjering James C.Williams, Titanium, springer.
4. Roger C. Reed, The Super alloys Fundamentals and Applications, Cambridge university press.
5. Valim Levitin - High temperature strain of metals and alloys - physical fundamentals, Wiley-VCH (2006).
6. https://www.phase-trans.msm.cam.ac.uk/teaching.html

MODEL QUESTION PAPER

MATERIALS IN MANUFACTURING - (HONORS) - MET -296

Max. Marks : 100 **Duration : 3 Hours**

Part – A

Answer all questions.

Answer all questions, each question carries 3 marks

1. NASA's Parker solar probe will be the first-ever mission to "Touch" the Sun. The spacecraft, about the size of a small car, will travel directly into the Sun's atmosphere about 4 million miles from the earth surface. Postulate the coolant used in the parker solar probe with chemical bonds.
2. Explain the structural parameters in time and creep curve for Nickel.
3. Explain the characteristics required for high-temperature materials
4. Explain the ways and means to improve super alloy cleanliness
5. What are the elements causing brittle phase formation in super alloys.
6. Explain the process and need of stress relieving used for super alloys
7. The preferred growth direction of a single-crystal superalloy is (100) Why?
8. Where is hundred percentage pure Titanium is used?
9. What are the special attributes of marging steel welded joint after ageing process?
10. How the structure of intermetallics are determined ?

PART -B

Answer one full question from each module.

MODULE -1

11. a. Explain the basic mechanism involved for metal deformation (7 marks).

    b. Explain process involved in high temperature strain of metals and alloys (7 marks).

OR

12. What are the roles played by the fan, compressor, combustor and turbine arrangements in a typical gas turbine engine? How do these affect (i) the pressure and (ii) the average temperature of the gas stream? Explain why your findings justify the use of nickel based superalloys in the combustor and turbine sections, but not in the compressor regions (14 marks).

MODULE -2

13. Explain the justification for the development of super alloys as high temperature alloys (14 marks).

OR

14. Explain the conditions of freckles, three rings and white spots formation and its implications (14 marks).

MODULE -3

15. Explain with neat sketches of different strengthening mechanisms of super alloys with its microstructure (14 marks).

OR

16. Explain different types of heat treatments employed for super alloys (14 marks).

MODULE -4

17. The materials used for high-pressure turbine blade aerofoils are often referred to as single-crystal superalloys. Explain why the use of the term ‘single-crystal’ is disingenuous (14 marks).

OR

18. Explain the process of closed die forging for Titanium alloy manufacturing (14 marks).

MODULE -5

19a. Explain the different reaction in austenite in maraging steel (7 marks).

19b. Explain the Maraging steel hardness produced with aging time versus aging time and different temperatures with neat sketches (7 marks).

OR

20a. Explain the synergetic effect of cobalt and molybdenum in maraging steel with graphs and sketch (7 marks).

20b. Explain structures of $MgCu_2$, $MgZn_2$, $MgNi_2$ with neat sketches (7 marks).

Course content and lecture schedules.

Module	TOPIC	No. of hours	Course outcomes
1.1	Earlier and present development of atomic structure- Primary bonds: Secondary bonds - crystallography-miller indices- slip- crystallization - frank reed source	1	CO1
1.2	Structural parameters in high-temperature deformed metals: structural parameters.	2	CO1
1.3	Dislocation structure - distances between dislocations in sub-boundaries - sub-boundaries as dislocation sources and obstacles.	3	CO1
1.4	Dislocations inside sub-grains - vacancy loops and helicoids - structural peculiarities of high-temperature deformation (levitin).	3	
2.1	Characteristics of high-temperature materials - The superalloys as high-temperature materials.	3	CO1 CO2
2.2	The requirement: the gas turbine engine- Larson–Miller approach for the ranking of creep performance		
2.3	Development of the super alloys- Nickel as a high-temperature material: justification. (Reed).	2	CO2
2.4	Super alloy production methods:- melt routes for super alloys, characteristics, process parameters, application of each process Vacuum induction melting (VIM), Vacuum arc remelting (VAR), VIM, electroslag remelting (ESR),VIM, ESR, VAR.	3	CO2 CO3
2.5	Freckles, conditions of freckles, three rings, white spot- Super alloy cleanliness: ways and means to improve super alloy cleanliness, advantages of improved cleanliness, homogenization oxide cleanliness. (ASM).	2	CO3
3.1	Superalloys:- metallurgy of superalloys, superalloy characteristics - applications - service temperatures for superalloys.	1	CO2

3.2	Wrought superalloys, cast superalloys, properties of superalloys, mechanical properties and the application of superalloys, selecting superalloys.	1	CO2
3.3	Crystal structures, phases in superalloys, Iron-Nickel-base superalloys, Nickel-base superalloys, Cobalt-base superalloys, alloy elements and microstructural effects in superalloys, elements causing brittle phase formation, detrimental tramp elements, elements producing oxidation and hot corrosion resistance.	3	CO2
3.4	Microstructure, gamma prime, gamma double prime, Carbide and Boride phases, strengthening mechanisms: precipitate, gamma prime, gamma double prime, Carbides, M7C3 Carbides, Borides and other beneficial minor elements.	3	CO5
3.5	Heat treatment types:- stress relieving, annealing, quenching, precipitation, (ASM).	1	CO2
4.1	Single-crystal super alloys for blade applications:- directional solidification, heat transfer, formation of defects during directional solidification - mechanical behavior of the single-crystal super alloys, performance in creep, performance in fatigue (Reed).	3	CO4
4.2	Titanium: Ti-based binary phase diagram - production of ingot, Vacuum Arc Remelting - effect of forging temperature and forging pressure - closed die forgings - shear bands - pickling of titanium - Ti alloys - scrap recycling -problems in machining Titanium - welding of titanium - Heat Treatment of Ti - properties of titanium aluminides - applications.	4	CO2 CO5
4.3	Niobium: Production of niobium - niobium alloys - niobium in steel making – niobium alloys characteristics and applications- Niobium products for the superalloy industry.	2	CO2
5.1	Molybdenum: Ferromolybdenum - production of molybdenum – properties - effect of molybdenum alloying on hot strength, corrosion resistance, and toughness – applications - TZM, TZC.	2	CO2
5.2	Maraging steel:- Maraging steel chronology - reaction in austenite - austenite to martensite transformation- reaction in martensite - time of maraging - precipitate size - fracture toughness - welding and ageing attributes - superior features - applications - cobalt free maraging steel and comparisons.	4	CO2 CO4
5.3	Intermetallics:- Electronegativity, characteristics, property prediction - phase diagrams:- Magnesium - Lead, Copper – Zinc, Nickel -Titanium phase diagram - - The Hume-Rothery phases, electron phases /compounds, laves phases - Strukturbericht C15, C14, C36, etc - structures of $MgCu_2$, $MgZn_2$, $MgNi_2$.	3	CO2 CO4

SEMESTER V

CODE MET301	COURSE NAME MECHANICS OF MACHINERY	CATEGORY	L	T	P	CREDIT
		PCC	3	1	0	4

Preamble:

This course aims to introduce the students to the fundamentals of the kinematics of various mechanisms and also its analysis for its displacement, velocity, and acceleration. The course will also cover the design of cams, theory and analysis of gears, gear trains and synthesis of mechanisms. The static force analysis of planar mechanisms and concept of gyroscopic couple along with its effect has also been included. This course also aids students in estimating unbalance in rotating and reciprocating masses and suggesting methods to overcome it.

Prerequisite: Engineering Mechanics (EST 100)

Course Outcomes: After the completion of the course the student will be able to

CO 1	Explain the fundamentals of kinematics, various planar mechanisms and interpret the basic principles of mechanisms and machines
CO 2	Perform analysis and synthesis of mechanisms
CO 3	Solve the problem on cams and gear drives, including selection depending on requirement.
CO 4	Calculate the gyroscopic effect in various situations
CO 5	Analyse rotating and reciprocating masses for its unbalance

Mapping of course outcomes with program outcomes

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 12**
CO 1	2										
CO 2	3	3	3	2	2						
CO 3	3	3	2	2	2						
CO 4	3	2	1	1	1						
CO 5	3	2	2	1	2						

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	10
Understand	20	20	20
Apply	20	20	70
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1): Explain the fundamentals of kinematics, various planar mechanisms and their components

1. Define the terms Link, Kinematic chain, Mechanism & Machine.

2. Explain Grashof's law.

3 Apply Kutzbach criterion to find the mobility of mechanisms.

4.Sketch and explain the various inversions of slider crank chain/fourbar chain

Course Outcome 2 (CO2) : Perform analysis and synthesis of mechanisms

1. Find out the velocity and acceleration of links of various planar mechanisms

2. State and prove the Arnold Kennedy's three centre theorem

2. Derive an expression for the magnitude and direction of Coriolis component of acceleration

3. Design a four bar mechanism to generate a given function accurate upto 3 positions

4. Do the static force analysis of four bar/slider crank mechanisms with different loading conditions

Course Outcome 3 (CO3): Solve the problem on cams and gear drives, including selection depending on requirement

1. Why is a roller follower preferred over knife edge follower

2. Design a cam profile to suit the situations for the follower such as SHM, dwell, constant velocity, uniform acceleration cycloidal motion etc

3. What do you understand by the term "interference" as applied to gears

4. Find out the gear train values of simple ,compound and epicyclic gear trains

Course Outcome 4 (CO4): Calculate the gyroscopic effect in various situations

1. What do you understand by Gyroscopic couple? Derive its formula for its magnitude.

2. Explain the effect of the gyroscopic couple on the reaction of the four wheels of a vehicle negotiating a curve.

3. Describe the working of a gyroscope.

4. How does gyroscopes help in guidance?

Course Outcome 5 (CO5): Analyse rotating and reciprocating masses for its unbalance

1. Distinguish between static balancing and dynamic balancing

2. Find out the magnitude and position of balancing masses required to balance unbalanced masses rotating in different planes.

3. What do you mean by primary and secondary unbalanced forces?

4. Find out the value of unbalanced primary force, primary couple, secondary force and secondary couple.

MODEL QUESTION PAPER

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIFTH SEMESTER B. TECH DEGREE EXAMINATION

Course Code: MET301

Course Name: MECHANICS OF MACHINERY

Max. Marks: 100 **Duration: 3 Hours**

PART – A

(ANSWER ALL QUESTIONS, EACH QUESTION CARRIES 3 MARKS)

1. Find out the degree of freedom in the following cases.

2. Describe the motion of the following items as pure rotation, pure translation or complex planar motion.

a) The hand of a clock **b)** The pen in an XY plotter **c)** connecting rod of an IC engine

3. A rod of length 1m with its one end fixed at origin is oriented in the positive X direction. It rotates in the XY plane with an angular velocity of 10rad/s clockwise direction and angular acceleration of 10rad/s^2 in the counter clock wise direction at a particular instant. Find out the total acceleration experienced at the free end.

4. Obtain the expression for velocity when the cam follower motion is cycloidal in nature.

5. How do we bring interchangeability of gears?

6. What do you mean by type synthesis?

7. Define the term 'friction circle'

8. How does a gyroscope help in guidance of aircrafts?

9. Does a rotor which is statically balanced require dynamic balancing?

10. Why do we go for partial balancing in the case of balancing of reciprocating masses?

Part B

(ANSWER ONE FULL QUESTION FROM EACH MODULE)

MODULE – I

11. a) Draw the inversions of the mechanism shown in Figure 1 which leads to double crank, double rocker and crank rocker mechanisms. Describe the nature of motion of each link in each case also **(9 marks)**

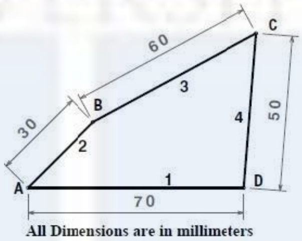


Figure-1

b) What are binary, ternary and quaternary links? **(5 marks)**

12. In the figure 2 given below the angular velocity of the crank OA is 600 r.p.m. Determine the linear velocity of the slider and angular velocity of all other links. The dimensions of various links are: OA=28 mm; AB = 44 mm; BC = 49 mm and BD = 46 mm. The centre distance between centres of rotation O and C is 65mm.The path of travel of slider is 11 mm below the fixed-point C **(14 marks)**

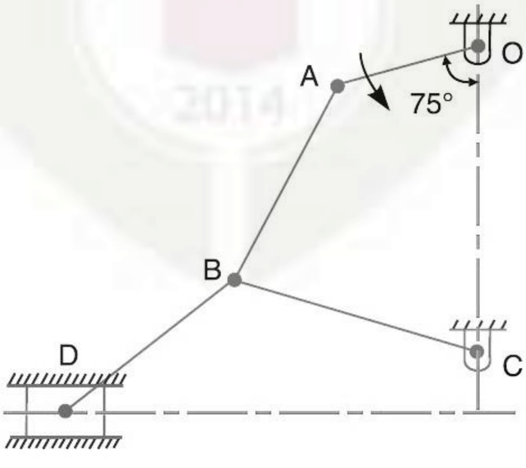


Figure-2

MODULE – II

13. **a)** What is meant by Coriolis component of acceleration. In which case does it occur? How is its direction determined? **(9 marks)**

b) A link OB rotating with a constant angular velocity of 2 rad/s in the counter clockwise direction and a block is sliding radially outwards on it with a uniform velocity of 0.75 m/s with respect to the rod as shown in the figure 3 below. Given OA =1 m and link OB is inclined to the positive X axis by 45°.Find out the absolute acceleration of block at A in magnitude and direction. **(5 marks)**

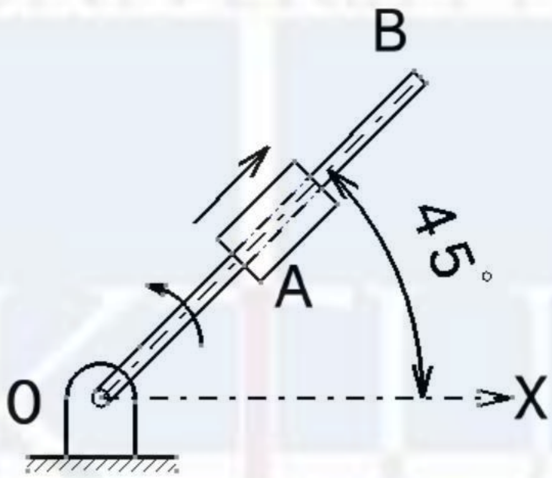


Figure-3

14. A cam rotating at 150 rpm operates a reciprocating follower of radius 2.5 cm. The follower axis is offset by 2.5 cm to the right. The least radius of the cam is 5 cm and the stroke of the follower is 5 cm. ascent and descent with take place by uniform acceleration and retardation. Ascent take place during 75° and descent during 90° of cam rotation. Dwell between ascent and descent is 60°. Draw the cam profile. Also sketch velocity and acceleration diagrams and mark salient values. **(14 marks)**

MODULE – III

15. In an epicyclic gear train as shown in Figure 4 the internal wheels A and B and the compound wheels C & D rotate independently about axis O. The wheels E and F rotate on pins fixed to the arm G.E gears with A and C and F gears with B and D. All wheels have the same module and the number of teeth are:

$T_C = 28$, $T_D = 26$, $T_E = T_F = 18$

i) Sketch the arrangement

ii) Find the number of teeth on A and B

iii) If the arm G makes 100 r.p.m clockwise and A is fixed, find the speed B

iv) If the arm G makes 100 r.p.m clockwise and wheel A makes 10 r.p.m counter clockwise, find the speed of wheel B **(14 marks)**

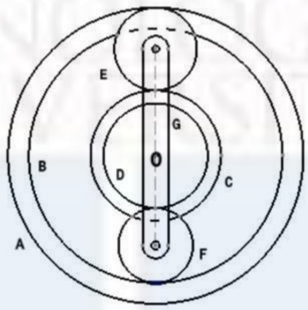


Figure-4

16. **a)** Design a four bar crank rocker to give 45° of rocker motion with a time ratio of 1:1.25 with 45° output rocker motion. **(9 marks)**

b) Design a slider crank mechanism to coordinate two positions of the input link and the slider for the following angular and linear displacement of the input link and slider respectively.

$\theta_{12} = 30°$ & $S_{12} = 100$ mm **(5 marks)**

MODULE – IV

17. The applied load on the piston of an offset slider-crank linkage shown in Fig. is 100 N, and the coefficient of friction between the slider and the guide is 0.27, using any method ,determine the magnitude and sense of torque T_2 applied on OA for the static equilibrium of the linkage. **(14 marks)**

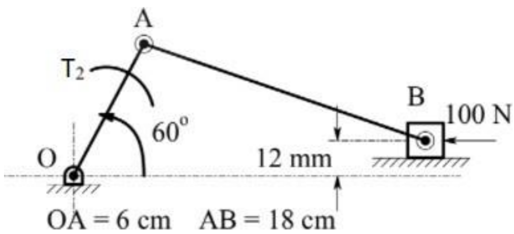


Figure-5

18 a) The wheels of a motor cycle have a moment of inertia of 5 kg m^2 and the engine parts, a moment of inertia of 0.35 kgm^2. The wheel axles and the crank shaft of the engine are all parallel to each other. If the ratio of reduction gears is 4:1, the wheel diameter is 700 mm, determine the magnitude and direction of the gyroscopic couple when the motor cycle negotiates a curve of 50 m radius at a speed of 50 km/hr. If the mass of the motor cycle with rider is 250 kg with centre of gravity at 65 cm above the ground in vertical position, determine the speed of the motor cycle rounding a curve of 60 m if the road condition permits an angle of heel of 45°. **(10 marks)**

b) Explain spin vector, precession vector, gyroscopic applied torque vector and gyroscopic reactive torque vector. **(4 marks)**

MODULE – V

19. A shaft carries four masses A, B, C and D which are placed in parallel planes perpendicular to the longitudinal axis. Th unbalanced masses at planes B and C are 3.6 kg and 2.6kg respectively and both are assumed to be concentrated at a radius of 25mm while the masses in planed A and D are both at a radius of 40mm.The angle between the planes B and C is 100° and that between B and A is 190°, both angles being measured in counter clock wise direction from the plane B .The planes containing A and B are 250mm apart and those containing B and C are 500mm.If the shaft is to be completely balanced ,determine

i) Masses at the planes A and D

ii) the distance between the planes C and D

iii) the angular position of the mass D **(14 marks)**

20. A five cylinder in-line engine running at 750 r.p.m. has successive cranks 144° apart, the distance between the cylinder centre lines being 375 mm. The piston stroke is 225mm and the ratio of the connecting rod to the crank is 4. Examine the engine for balance of primary and secondary forces and couples. Find the maximum values of these and the position of the central crank at which these maximum values occur. The reciprocating mass for each cylinder is 15 kg. **(14 marks)**

Syllabus

Module 1

Introduction to kinematics and mechanisms - various mechanisms, kinematic diagrams, degree of freedom- Grashof's criterion, inversions, coupler curves mechanical advantage, transmission angle. straight line mechanisms exact, approximate. Displacement, velocity analysis– relative motion - relative velocity. Instantaneous centre -Kennedy's theorem.

Module 2

Acceleration analysis- Relative acceleration - Coriolis acceleration - graphical and analytical methods.
Cams - classification of cam and followers - displacement diagrams, velocity and acceleration analysis of SHM, uniform velocity, uniform acceleration, cycloidal motion Graphical cam profile synthesis, pressure angle.

Module 3

Gears – Classification- terminology of spur gears – law of gearing -tooth profiles- involute spur gears- contact ratio - interference - backlash - gear standardization – interchangeability. Gear trains - simple and compound gear trains - planetary gear trains.

Kinematic synthesis (planar mechanisms) - type, number and dimensional synthesis – precision points. Graphical synthesis for motion - path and prescribed timing - function generator. 2 position and 3 position synthesis – overlay Method. Freudenstein's equation.

Module 4

Static force analysis- Analysis of four bar linkages and slider crank mechanism, graphical method, Matrix method, principle of virtual work. Analysis of four bar and slider crank mechanisms with sliding and pin friction.

Gyroscopic couples-spin, precession and applied gyroscopic couple vectors-effects on the stability of two wheelers, four wheelers, sea vessels and air crafts, application of gyroscopes

Module 5

Static balancing-dynamic balancing-balancing of several masses in the same plane-several masses in different planes-graphical and analytical method-force and couple polygons.

Balancing of reciprocating masses -Single cylinder engine-multi cylinder engine -V-engine

Text Books

1. Ballaney P. L., Theory of Machines and Mechanisms, Khanna Publishers,2005
2. S. S. Rattan, Theory of Machines, Tata Mc Graw Hill,2009

Reference Books

1. C. E. Wilson, P. Sadler, Kinematics and Dynamics of Machinery, Pearson Education,2005.
2. D.H. Myskza, Machines and Mechanisms Applied Kinematic Analysis, Pearson Education,2013
3. G. Erdman, G. N. Sandor, Mechanism Design: Analysis and synthesis Vol I & II, Prentice Hall of India,1984.
4. Ghosh, A. K. Malik, Theory of Mechanisms and Machines, Affiliated East West Press,1988
5. J. E. Shigley, J. J. Uicker, Theory of Machines and Mechanisms, McGraw Hill,2010
6. Norton, Kinematics and Dynamics of Machinery, Tata McGraw Hill,2009

Course Contents and Lecture Schedule

No	Topic	No. of lectures
1	**Module-1-**	**10 Hours**
1.1	Introduction to kinematics and mechanisms	1 Hr
1.2	Various mechanisms	2 Hr
1.3	Kinematic diagrams, degree of freedom, Grashof’s criterion	2 Hr
1.4	Inversions	1 Hr
1.5	Coupler curves mechanical advantage, transmission angle.	1 Hr
1.6	Straight line mechanisms exact, approximate	1 Hr
1.7	Displacement, velocity analysis, Kennedy’s theorem.	2 Hr
2	**Module 2-**	**10 Hours**

2.1	Acceleration analysis- Relative acceleration - Coriolis acceleration -	1 Hr
2.2	Graphical and analytical methods. .	2Hr
2.3	Cams - classification of cam and followers	1 Hr
2.4	Displacement diagrams, velocity and acceleration analysis of SHM,	2 Hr
2.5	Uniform velocity,uniform acceleration and cycloidal motion	1 Hr
2.5	Graphical cam profile synthesis, pressure angle.	2 Hr
2.6	Analysis of tangent cam with roller follower and circular cam with flat follower	1 Hr
3	**Module-3**	**9 Hours**
3.1	Gears – terminology of spur gears – law of Gearing	1 Hr
3.2	involute spur gears - contact ratio- interference - backlash - gear standardization-interchangeability	1 Hr
3.3	Gear trains - simple and compound gear trains - planetary gear trains	2 Hr
3.4	Kinematic synthesis (planar mechanisms) - type, number and dimensional synthesis – precision points.	2 Hr
3.5	Graphical synthesis for motion - path and prescribed timing - function generator. 2 position and 3 position synthesis	2 Hr
3.6	Overlay Method. Freudenstein's equation	1 Hr
4	**Module-4-**	**8 Hours**
4.1	Static force analysis- Analysis of four bar linkages and slider crank mechanism	2 Hr
4.2	Graphical method, Matrix method	1 Hr
4.3	principle of virtual work	1 Hr
4.4	Analysis of four bar and slider crank mechanisms with sliding and pin friction.	1 Hr

4.4	Gyroscopic couples-spin, precession and applied gyroscopic couple vectors	2 Hr
4.5	Effects on the stability of two wheelers **,** Four wheelers, sea vessals and air crafts	1 Hr
5	**Module-5- Kinematics-synthesis**	**8 Hours**
5.1	Static balancing-dynamic balancing-	2 Hr
5.2	balancing of several masses in the same plane	1 Hr
5.3	several masses in different planes-graphical and analytical method	1 Hr
5.4	force and couple polygons	1 Hr
5.5	Balancing of reciprocating masses -Single cylinder engine	1 Hr
5.6	multi cylinder engine-v engine-inline engine	2 Hr

CODE MET303	COURSE NAME THERMAL ENGINEERING	CATEGORY	L	T	P	CREDIT
		PCC	3	1	0	4

Preamble: This course involve the application of principles studied in thermodynamics to different energy conversion systems like steam turbine, steam nozzle, steam powerplant, IC engines and refrigeration systems. This course also covers the methods for improving and evaluating the performance of different energy conversion systems. This course also helps to understand the combustion phenomenon in IC engines.

Prerequisite: MET202 Engineering Thermodynamics

Course Outcomes: After the completion of the course the student will be able to

CO 1	Explain the working of steam power cycle and related components
CO 2	Discuss the working of steam turbines and methods for evaluating the performance
CO 3	Illustrate the performance testing and evaluation of IC engines
CO 4	Explain the combustion phenomenon and pollution in IC engines
CO 5	Discuss the principles of refrigeration and air-conditioning and basic design considerations

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	**3**	3	2									
CO 2	**3**	3	2									
CO 3	**3**	3	2									
CO 4	**3**	3	2									
CO 5	**3**	3	2									

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	10
Understand	20	20	20
Apply	20	20	70
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. In a reheat Rankine cycle, steam at a pressure of 40 bar and 300°C is expanded through a turbine to a pressure of 4 bar. It is then heated at a constant pressure to 300° C and then expanded to 0.1 bar. Estimate the work done per kg of steam flowing through the turbine, the amount of heat supplied during the reheat process and the cycle efficiency. Neglect pump work.

2. Dry saturated steam enters a frictionless adiabatic nozzle with negligible velocity at a temperature of 300 °C. It is then expanded to a pressure of 40 bar. For a mass flow rate of 2 kg/s, calculate the exit velocity of the steam.

3. With the help of a figure explain the working of Babcock and Wilcox boiler.

Course Outcome 2 (CO2):

1. In an impulse steam turbine, steam issues from the nozzle with a velocity of 1200 m/s. The nozzle angle is 20^o and the mean blade velocity is 400 m/s. The inlet and outlet blade angles are equal. The blade velocity coefficient is 0.8. The mass of steam flowing through the turbine per hour is 950 kg. Calculate: (i) Blade angles. (ii) Relative velocity of steam entering the blades (iii) Tangential force on the blades. (iv) Power developed. (v) Blade efficiency.

2. In a reaction turbine, the mean blade speed is 150 m/s and the ratio of blade speed to steam speed is 0.625. The outlet angles of fixed and moving blades are 20^o and 30^o respectively. Calculate (i) the degree of reaction (ii) the adiabatic enthalpy drop in a pair of blade rings and (iii) the gross stage efficiency. The specific volume of steam at fixed blade outlet is 0.567 m^3 and at moving blade outlet 0.6 m^3. Assume the efficiency of blades when considered as nozzles 0.90 and k^2 = 0.86, where k is the blade velocity coefficient.

3. Derive the conditions for maximum efficiency of a Parsons reaction turbine.

4. Discuss the means of improving the performance of a steam turbine.

Course Outcome 3(CO3):

1. A 4-cylinder four stroke petrol engine is working based on the following data: Air-fuel ratio by weight = 15:1, calorific value of the fuel = 45000 kJ/kg, mechanical efficiency = 80 %, air- standard efficiency = 54 %, relative efficiency = 70 %, volumetric efficiency = 75 %, stroke/bore ratio = 1.25, suction conditions = 1 bar and 30 ^{o}C, r.p.m. = 2500, brake power = 70 kW. Calculate: (i) Compression ratio. (ii) Indicated thermal efficiency. (iii) Brake specific fuel consumption. (iv) Bore and stroke.

2. Discuss the working of a rotary engine and its merits and demerits over conventional IC engines.

3. How Morse test and retardation test helps to find the friction power of an engine?

4. Explain the procedure for heat balance test and its significance.

Course Outcome 4 (CO4):

1. Explain equivalence ratio and its significance in IC engine combustion.

2. Explain different stages of SI engine combustion with the help of pressure-crank angle diagram.

3. Discuss detonation in SI engine, cause and effects and the engine variable influencing the same.

4. Explain different pollution control methods employed for reducing the emissions in IC engines.

Course Outcome 5 (CO5):

1. Derive the expression for COP of an ideal air refrigeration cycle.

2. A food storage locker with R12 refrigerant requires a refrigeration of 2400 kJ/min. capacity has an evaporator temperature of 263 K and a condenser temperature of 303 K.The refrigerant is sub cooled by 6 ^{o}C before entering the expansion valve and vapour is superheated by 7 ^{o}C before leaving the evaporator coil. The refrigeration compressor is a two cylinder single acting with stroke equal to 1.25 times the bore and operates at 1000 rpm. Calculate i) Mass of refrigerant circulated/min. ii) Heat removed by condenser/min iii) Theoretical bore and stroke.

3. Sensible and latent loads on a space are 50 kW and 10 kW respectively. Cold and dehumidified air at 10 ^{o}C DBT and 90 % RH is used to maintain the space condition at 24 ^{o}C DBT. Find i) RSHF ii) space relative humidity and iii) mass flow rate of supply air?

MODEL QUESTION PAPER

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

V SEMESTER BTECH DEGREE EXAMINATION

MET303: THERMAL ENGINEERING

Maximum: 100 Marks Duration:3 hours

Use of Steam tables, Refrigeration tables, Charts and Psychrometric chart is permitted.

PART A

Answer all questions, each question carries 3 marks

1. Explain Rankine cycle with help of a T-S diagram.
2. Differentiate between fire tube boiler and water tube boiler.
3. List the difference between throttle governing and nozzle governing.
4. Explain degree of reaction of a steam turbine.
5. With the help of a diagram explain turbocharging.
6. Explain the procedure of Morse test.
7. Discuss about pollutants coming from a CI engine.
8. What do you meant by Octane number?
9. Why reversed Carnot cycle is practically impossible to execute?
10. Define bypass factor and mention its significance. (10×3=30 Marks)

PART B

Answer one full question from each module

MODULE 1

11. a) Steam at a pressure of 15 bar and 250 ^oC is expanded through a turbine to a pressure of 4 bar. It is then reheated at constant pressure to initial temperature of 250 ^oC and finally expanded to condenser pressure of 0.1 bar. Calculate efficiency of the cycle. What will be the efficiency if reheating is not employed? Pump work can be neglected. (8 marks)

    b) Derive the expression for mass flow rate of steam through a nozzle and obtain the critical pressure ratio. (6 marks)

12. a) With the help of a neat figure explain the working of a Benson boiler. What are its merits over other boilers? (8 marks)

    b) With the help of T-s and p-h diagram explain the significance of binary vapour cycle. (6 marks)

MODULE 2

13. a) Derive the condition for maximum efficiency of a reaction turbine. (6 marks)

    b) With the help of figures enumerate the difference between pressure compounding and velocity compounding of steam turbines. (8 marks)

14. a) What do you meant by reheat factor? List the parameters influencing the value of reheat factor. (4 marks)

    b) In an impulse steam turbine, steam issues from the nozzle with a velocity of 1200 m/s. The nozzle angle is 20^o and the mean blade velocity is 400 m/s. The inlet and outlet blade angles are equal. The blade velocity coefficient is 0.8. The mass of steam flowing through the turbine per hour is 950 kg. Calculate: (i) Blade angles. (ii) Relative velocity of steam entering the blades. (iii) Tangential force on the blades. (iv) Power developed. (v) Blade efficiency. (10 marks)

MODULE 3

15. a) With the help of a neat figure explain the working of Wankel engine. Mention its merits and demerits over conventional IC engines. (9 marks)

    b) Discuss the effect of variable specific heat in actual cycle of IC engines.(5 marks)

16. a) The following observations were recorded during a trial of a four stroke single cylinder diesel engine for a trial duration of 30 min. Fuel consumption is 4 liters, Calorific value of fuel 43 MJ/kg, specific gravity of the fuel = 0.8, average area of indicator diagram = 8.5 cm^2, length of indicator diagram = 8.5 cm, spring constant= 5.5 bar/cm, brake load = 150 kg, spring balance reading = 20 kg, effective brake wheel diameter = 1.5 m, speed = 200 rpm, cylinder diameter = 30 cm, stroke = 45 cm. Calculate i) indicate power ii) brake power iii) mechanical efficiency iv) specific fuel consumption in kg/kWh and v) indicated thermal efficiency. (10 marks)

    b) Explain the concept of charge stratification in IC engines. (4 marks)

MODULE 4

17. a) With the help of pressure-crank angle diagram explain different stages of CI engine combustion. (8 marks)

    b) Explain the phenomenon of detonation in SI engine based on autoignition theory.

    (6 marks)

18. a) With the help of figures compare different types of SI engine combustion chambers. (8 marks)

    b) Discuss any two emission control methods employed in reducing the emission of CI engine. (6 marks)

MODULE 5

19. a) A freezer of 20 TR capacity has evaporator and condenser temperature of -30 ^oC and 25 ^oC respectively. The refrigerant R-12 is sub-cooled by 4 ^oC before entering the expansion valve and is superheated by 5 ^oC before entering the evaporator. If a six cylinder single acting compressor with stroke equal to bore running at 1000 rpm. is used. Determine i) COP ii) Theoretical piston displacement per minute iii) Theoretical bore and stroke. (9 marks)

    b) Derive an expression for COP of a Reversed Brayton cycle for air refrigeration system. (5 marks)

20. a) 2.5 kg of air is cooled and dehumidified from 30 ^oC DBT, 40% RH to 15 ^oC DBT & 80% RH in a cooling and dehumidifying coil. Find (i) ADP, (ii) Bypass Factor and (iii)Heat Transfer. If bypass factor is halved keeping the ADP same find (iv) exit air condition and (v) Heat Transfer. (10 marks)

    b) Define i) DPT ii) RH ii) SHF and iv) ADP. (4 marks)

Syllabus

Module 1

Steam engineering- Rankine cycle, Modified Rankine cycle, Relative efficiency, Improvement in steam cycles-Reheat, Regenerative and Binary vapour cycle. Steam Boilers: Types of boilers, Cochran boiler, Babcock and Wilcox boiler, Benson boiler, La Mont boiler, Loeffler boiler, Velox boiler, Boiler Mountings and Accessories. Steam nozzles: -Types of nozzle,Velocity of steam, mass flow rate, critical pressure ratio and its significance, effect of friction, super saturated flow.

Module 2

Steam turbines: classification, compounding of turbines-pressure velocity variation, velocity diagrams, work done, efficiency, condition for maximum efficiency, multistage turbines-condition line, stage efficiency. Steam turbine performance-reheat factor, degree of reaction, cycles with reheating and regenerative heating, governing of turbines.

Module 3

Actual cycle analysis of IC engines- Deviation of actual engine cycle from ideal cycle, variable specific heats. Rotary engines, Stratified charge engine, Super charging and turbo charging. Performance Testing of I C Engines- Indicator diagram, mean effective pressure. Torque, Engine power- BHP, IHP. Engine efficiency, mechanical efficiency, volumetric efficiency, thermal efficiency, relative efficiency and Specific fuel consumption. Morse test, Heat balance test and Retardation test.

Module 4

Combustion in I.C. Engines- Analysis of fuel combustion-A/F ratio, equivalence ratio, excess air. Combustion phenomena in S.I. engines; Ignition limits, stages of combustion in S.I. Engines, Ignition lag, velocity of flame propagation, auto ignition, detonation; effects of engine variables on detonation; theories of detonation, octane rating of fuels; pre-ignition; S.I. engine combustion chambers. Combustion in C.I. Engines; delay period; variables affecting delay period; knock in C.I. engines, Cetane rating; C.I. engine combustion chambers. Air pollution from I.C. Engine and its control: Pollutants from S.I. and C.I. Engines, Methods of emission control.

Module 5

Refrigeration– Reversed Carnot cycle, Air refrigeration system- Reversed Joule cycle. Vapour compression systems-simple cycle - representation on T- s and P- h Diagrams. Effect of operating parameters on COP, Methods of improving COP of simple cycle, Super heating and under cooling. Psychometric properties – specific humidity, relative humidity and degree of saturation, thermodynamic equations, enthalpy of moisture, DBT, WBT and DPT, psychrometers, psychometric chart. Psychometric processes- adiabatic mixing, sensible heating and cooling, humidifying and dehumidifying, air washer, bypass factor, sensible heat factor, Comfort and industrial air conditioning, Comfort air conditioning- factors affecting human comfort, Effective temperature, comfort chart, Summer air conditioning, factors affecting, cooling load estimation.

Text Books

1. Rudramoorthy , Thermal Engineering, McGraw Hill Education India, 2003.

2. R.K Rajput, Thermal Engineering, Laxmi publications, 2010.

3. Arora C. P, Refrigeration and Air-Conditioning, McGraw-Hill, 2008.

4. Arora S. C. and Domkundwar, Refrigeration and Air-Conditioning, Dhanpat Rai, 2010.

Reference Books

1. V. Ganesan, Fundamentals of IC engines, Tata McGraw-Hill, 2002.

2. J.B.Heywood, I.C engine fundamentals. McGraw-Hill, 2011.

3. Rathore, Thermal Engineering, McGraw Hill Education India, 2010.

4. Dossat. R. J, Principles of Refrigeration, Pearson Education India, 2002.

5. Stoecker W.F, Refrigeration and Air-Conditioning, McGraw-Hill Publishing Company, 2009.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1		
1.1	Steam engineering- Rankine cycle, Modified Rankine cycle, Relative efficiency, Improvement in steam cycles-Reheat, Regenerative and Binary vapor cycle.	4
1.2	Steam Boilers: Types of boilers, Cochran boiler, Babcock and Wilcox boiler, Benson boiler, , La Mont boiler, Loeffler boiler, Velox boiler, Boiler Mountings and Accessories.	3
1.3	Steam nozzles:-Types of nozzle- Velocity of steam, mass flow rate, critical pressure ratio and its significance, effect of friction, super saturated flow.	2
2		
2.1	Steam turbines: classification, compounding of turbines-pressure velocity variation, velocity diagrams.	3
2.2	Work done, efficiency, condition for maximum efficiency, multistage turbines-condition line, stage efficiency.	3
2.3	Steam turbine performance-reheat factor, degree of reaction, cycles with reheating and regenerative heating, governing of turbines.	3
3		

3.1	Actual cycle analysis of IC engines- Deviation of actual engine cycle from ideal cycle, variable specific heats.	2
3.2	Rotary engines, Stratified charge engine, Super charging and turbo charging.	2
3.3	Performance Testing of I C Engines- Indicator diagram, mean effective pressure. Torque, Engine power- BHP, IHP. Engine efficiency, mechanical efficiency, volumetric efficiency, thermal efficiency and relative efficiency, Specific fuel consumption.	3
3.4	Morse test, Heat balance test and Retardation test.	2
4		
4.1	Combustion in I.C. Engines- Analysis of fuel combustion-A/F ratio, equivalence ratio, excess air.	1
4.2	Combustion phenomena in S.I. engines; Ignition limits, stages of combustion in S.I. Engines, Ignition lag, velocity of flame propagation, auto ignition, detonation; effects of engine variables on detonation; theories of detonation, octane rating of fuels; pre-ignition; S.I. engine combustion chambers.	3
4.3	Combustion in C.I. Engines; delay period; variables affecting delay period; knock in C.I. engines, Cetane rating; C.I. engine combustion chambers.	3
4.4	Air pollution from I.C. Engine and its control: Pollutants from S.I. and C.I. Engines, Methods of emission control.	2
5		
5.1	Refrigeration– Reversed Carnot cycle, Air refrigeration system-Reversed Joule cycle.	2
5.2	Vapour compression systems-simple cycle - representation on T- s and P- h Diagrams. Effect of operating parameters on COP, Methods of improving COP of simple cycle, Super heating and under cooling.	2
5.3	Psychometric properties – specific humidity, relative humidity and degree of saturation- thermodynamic equations- enthalpy of moisture- DBT, WBT and DPT–psychrometers, psychometric chart.	1
5.4	Psychometric processes- adiabatic mixing, sensible heating and cooling, humidifying and dehumidifying, air washer, bypass factor, sensible heat factor.	2
5.5	Comfort and industrial air conditioning, Comfort air conditioning-factors affecting human comfort, Effective temperature, comfort chart, Summer air conditioning, factors affecting, cooling load estimation.	2

MET305	INDUSTRIAL & SYSTEMS ENGINEERING	CATEGORY	L	T	P	CREDIT
		PCC	3	1	0	4

Preamble:

This course is designed to facilitate the students to acquire knowledge about management principles and practices of an industry. It empowers the students to amalgamate their knowledge of materials management, inventory management, lean manufacturing, agile manufacturing, industrial relations and enterprise resource planning and thus inculcate the skills needed to apply these principles in an industry.

Prerequisite: NIL

Course Outcomes: After the completion of the course the student will be able to

CO 1	**Implement various tools and techniques in industrial engineering**
CO 2	**Calculate the inventory system for a given requirement**
CO 3	**Explain the importance of industrial relations**
CO 4	**Select the lean manufacturing tools to find and eliminate wastes**
CO 5	**Identify the framework of agile manufacturing**
CO 6	**Identify core and extended modules of enterprise resource planning**

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	**2**				2				2		2	2
CO 2	**3**			2						2	2	2
CO 3						1			2	2	1	2
CO 4	**2**	1		2	1						2	2
CO 5				2	1				2		2	2
CO 6	**2**				3						2	2

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	20
Understand	20	40	60
Apply	20		20
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance	: 10 marks
Continuous Assessment Test (2 numbers)	: 25 marks
Assignment/Quiz/Course project	: 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Calculate the breakeven point for the product.

2. What are the functions of Industrial Engineering?

3. What are the human factors to be considered while designing a new product?

Course Outcome 2 (CO2)

1. List various types of material handling equipments

2. Determine the optimum quantity to be ordered

3. Describe the role played by the materials management function in enabling an organisation to achieve profitability.

Course Outcome 3(CO3):

1. Define 'Job Satisfaction'.

2. Describe the causes of poor industrial relations.

3. What is meant by 'collective bargaining'?

Course Outcome 4 (CO4):

1.Compare the inventory levels in conventional and lean manufacturing systems.

2.Expand the Japanese terms of 5S

3.Describe the basic elements of lean manufacturing

Course Outcome 5 (CO5):

1. Describe the components of agile manufacturing system

2. List the measures that are used to measure innovation in agile production system.

3. How do strategic linkages aid the organisation to acquire agility?

Course Outcome 6 (CO6):

1. Enumerate ERP implementation stages.

2. With the aid of a block diagram, explain the construction and working of ERP framework.

3. Describe ERP related technology

Model Question paper

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIFTH SEMESTER B.TECH DEGREE EXAMINATION

MET305 INDUSTRIAL & SYSTEMS ENGINEERING

Max. Marks: 100 Duration: 3 Hours

PART A

Answer ALL questions, each carries 3 marks.

1. What are the human factors to be considered while designing a new product?
2. Describe the procedure followed while designing a product.
3. List various types of material handling equipments
4. Describe the concept of JIT manufacturing system
5. Describe the causes and effects of industrial disputes and how it can be eliminated
6. What are the methods of elimination of fatigue?
7. Expand the Japanese terms of 5S.
8. Describe the characteristics of agile manufacturing.
9. State the evolution of ERP.
10. What is Online Analytical Processing?

PART B

Module 1

11. a) How inventories are classified and costs associated by inventories? (5)

b) A manufacturer has to supply 10,000 units of product annually. The unit cost is Rs. 2 and it costs Rs.36 to place an order. The inventory carrying cost is estimated at 9% of average inventory investment. Determine 1. EOQ 2.Optimum number of orders to be placed per annum. 3. Minimum total cost of inventory (9)

12 a) What are the principles of good product design (10)

b) The fixed cost of producing a product in a company is Rs. 8,00,000. Variable cost per unit of the product is Rs. 30. Each unit of the product is going to be sold at a price of Rs. 180. Determine the breakeven point of this product. (4)

Module 2

13. Describe the role played by the materials management function in enabling an organisation to achieve profitability. (14)

14. a) What is meant by quantity discount? (4)

b) A retailer procures batteries for quartz watches and sells them to watch repair shops. The price paid by the retailer varies on the basis of the quantities of batteries procured by him. The quantity and the price/unit pattern offered to him are given below:

Quantity (Q)	Price per one unit of battery
$0 \le Q < 100$	Rs.20
$100 \le Q < 200$	Rs.18
$200 \le Q$	Rs.15

The monthly demand for the batteries is 600 units. The storage cost is 15% of unit cost of the battery and the cost of ordering is Rs.30 per order. Determine the optimum quantity to be ordered by the retailer so that the total cost of procurement is minimum. (10)

Module 3

15. (a) List any five objectives of Trade union. (5)

(b) Trace the history of Trade unionism. (9)

16 (a) Explain conditions to be met for maintaining good industrial relations. (7)

(b) Describe the causes of poor industrial relations. (7)

Module 4

17. (a) Enumerate the objectives and key principles of lean manufacturing paradigm. (7)

(b) Compare traditional and lean manufacturing paradigms. (7)

18. List and describe any ten components of agile manufacturing system. (14)

Module 5

19. Describe the key processes of “Customer Relationship Management”. (14)

20 a) With the aid of a block diagram, explain the construction and working of ERP framework. (7)

(b) Explain the differences between ‘Business Engineering’ and ‘Business Process Reengineering’. (7)

Syllabus

Module 1

Introduction to Industrial Engineering - Evolution of modern Concepts in Industrial Engineering - Functions of Industrial Engineering - Field of application of Industrial Engineering - Design function - Objectives of design- Development of designs- prototype, production and testing - Human factors in design - Principles of good product design- tolerance design- quality and cost considerations- product life cycle- standardization, simplification, diversification- concurrent engineering- comparison of production alternatives - Economic aspects- C-V-P analysis – simple problems.

Module 2

Introduction to materials management – objectives – Types of material handling equipments - principles of material handling –Material selection – value analysis – make or buy decisions-Purchasing and procedures. Basic inventory management - Inventory -Functions, Costs, Classifications - EOQ Models- Assumptions- Quantity discount model- Q system- P system- Reorder level - Simple problems- Concept of JIT manufacturing system.

Module 3

Industrial relations- Psychological attitudes to work and working conditions - fatigue- Methods of eliminating fatigue- Effect of Communication in Industry-Industrial safety-personal protective devices-, causes and effects of industrial disputes- Collective bargaining- Trade union - Workers participation in management.

Module 4

Principles of Lean Manufacturing(LM) – Basic elements of LM– Introduction to LM Tools- Concept of wastes in LM and their narration - stages of 5S and waste elimination - Conventional Manufacturing versus Lean Manufacturing - Need for LM. Agile manufacturing - Definition, business need, conceptual frame work, characteristics, and generic features - Approaches to enhance ability in manufacturing - Managing people in agile organization

Module 5

Introduction of enterprise resource planning (ERP)- Concept of Enterprise, ERP Overview - Integrated information system - Myths about ERP – Evolution of ERP- Benefits of ERP implementation - Success and failure factors of ERP implementation - Small, medium and large enterprise vendor solutions- ERP and related technology: Business intelligence (BI), E-Commerce and E-Business, Business Process Reengineering (BPR), Data warehousing, Data mining, Online Analytical Processing(OLAP), Product lifecycle management(PLC), Supply chain management(SCM), Customer relationship management (CRM)- ERP implementation challenges - Emerging trends on ERP

Text Books

1. Martand T. Telsang, "Industrial Engineering & Production Management", S. Chand and Company Limited, 2018.

2. M. Mahajan, "Industrial Engineering & Production Management", Dhanpat Rai & Co. (P) Limited, 2015.

3. O. P. Khanna, "Industrial Engineering and Management", Dhanpat Rai Publications, 2018.

4. James P. Womack, Daniel T. Jones and Daniel Roos, "The Machine That Changed the World", Free Press, New York, 2007.

5. Alexis Leon, "ERP Demystified", Tata McGraw Hill Education Private Limited, New Delhi, 2008.

Reference Books

1. Kjell Zandin and Harold Maynard, "Maynard's Industrial Engineering Handbook", McGraw-Hill Education, 2001.

2. Philips E. Hicks, "Industrial Engineering and Management – A new perspective", McGraw Hill International Editions, New York, 1994.

3. B. Kumar "Industrial Engineering and Management ", Khanna Publishers,2013.

4. S.R. Devadasan, V. Mohan Sivakumar, R. Murugesh and PR Shalij, "Lean and Agile Manufacturing: Theoretical, Practical and Research Futurities" PHI Learning private Limited, New Delhi, 2012.

5. Ravi Shankar, "Industrial Engineering and Management", Golgotia Publications Pvt Ltd, NewDelhi, 2009.

Course Contents and Lecture Schedule

No	**Topic**	**No. of Lectures**
1	Introduction to Industrial Engineering	
1.1	Evolution of modern Concepts in Industrial Engineering - Functions of Industrial Engineering - Field of application of Industrial Engineering	2
1.2	Design function - Objectives of design- Development of designs- prototype, production and testing - Human factors in design - Principles of good product design- tolerance design	2
1.3	Quality and cost considerations- product life cycle- standardization, simplification, diversification- concurrent engineering	2
1.4	Comparison of production alternatives - Economic aspects- C-V-P analysis – simple problems	2
2	Introduction to materials management	

2.1	Objectives – Types of material handling equipments	1
2.2	Principles of material handling –Material selection – Value analysis	2
2.3	Make or buy decisions-Purchasing procedure	1
2.4	Inventory -Functions, Costs, Classifications	1
2.5	EOQ Models- Assumptions- Quantity discount model- Q system- P system- Reorder level - Simple problems, JIT	3
3	Industrial relations	
3.1	Psychological attitudes to work and working conditions	1
3.2	Fatigue- Methods of eliminating fatigue	1
3.3	Effect of Communication in Industry-Industrial safety-personal protective devices	2
3.3	Causes and effects of industrial disputes- Collective bargaining	2
3.4	Trade union - Workers participation in management	1
4	Lean Manufacturing and Agile manufacturing	
4.1	Principles of Lean Manufacturing(LM) – Basic elements of LM– Introduction to LM Tools	2
4.2	Concept of wastes in LM and their narration	1
4.3	Stages of 5S and waste elimination	2
4.4	Conventional Manufacturing versus Lean Manufacturing - Need for LM.	1
4.5	Agile manufacturing – Definition , business need	1
4.6	Agile manufacturing - conceptual frame work, characteristics, and generic features	2
4.7	Approaches to enhance ability in manufacturing -	1
4.8	Managing people in agile organization	1
5	Introduction of Enterprise Resource Planning	
5.1	Introduction of enterprise resource planning (ERP)- Concept of Enterprise, ERP Overview - Integrated information system - Myths about ERP – Evolution of ERP	2
5.2	Myths about ERP - Basic ERP concepts - Small, medium and large enterprise vendor solutions	2
5.3	Benefits of ERP implementation, Success and failure factors of ERP implementation	1
5.4	Business intelligence (BI), E-Commerce and E-Business, Business Process Reengineering (BPR)	2
5.5	Data warehousing, Data mining, Online Analytical Processing(OLAP), Product lifecycle management(PLC)	2
5.6	Supply chain management(SCM), Customer relationship management (CRM)	1
5.7	ERP implementation challenges, Emerging trends on ERP	1

MET 307	MACHINE TOOLS AND METROLOGY	CATEGORY	L	T	P	Credits
		PCC	3	1	0	4

Preamble:

To develop knowledge of appropriate process parameters to be used for various machining operations.
Understand the fundamentals of modem quality concepts. Be able to apply statistical techniques.
Understand the principles and operation of precision measurement tools and equipment used in modern manufacturing.

Prerequisite: MET 205Metallurgy and Material Science and PHT 110 Engineering Physics

Course Outcomes - At the end of the course students will be able to

CO 1	Analyze various machining process and calculate relevant quantities such us velocities, forces and powers.
CO 2	Analyze of the tool nomenclature with surface roughness obtainable in each machining processes.
CO 3	Understand the limitations of various machining process with regard to shape formation and surface texture.
CO 4	Demonstrate knowledge of the underlying principles of measurement, as they relate to mechanical measurement, electronic instrumentation, and thermal effects.
CO 5	Get an exposure to advanced measuring devices and machine tool metrology.

Mapping of course outcomes with program outcomes (Minimum requirements)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	2	3	-	-	-	-	-	-	-		2	1
CO 2	2	3	-	-	-	-	-	-	-	-	2	1
CO 3	2	1	-	2	2	-	-	-	-	-	-	2
CO 4	3	-	2	-	-	-	-	-	-	-	2	2
CO 5	2	-	-	2	3	-	-	-	-	-	-	3

ASSESSMENT PATTERN

Bloom's taxonomy	Continuous Assessment Tests		End Semester Examination (Marks)
	Test 1 (Marks)	Test 11 (Marks)	
Remember	25	25	25
Understand	15	15	15
Apply	30	25	30
Analyze	10	10	10
Evaluate	10	15	10
Create	10	10	10

Mark distribution

Total Marks	CIE marks	ESE marks	ESE duration
150	50	100	3 Hours

Continuous Internal Evaluation (CIE) Pattern:

Attendance	10 marks
Regular class work/tutorials/assignments/self learning (Minimum 3 numbers)	15 marks
Continuous Assessment Test(Minimum 2numbers)	25 marks

End semester pattern:-There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions.

Part B contains 2 questions from each module of which student should answer anyone. Each question can have maximum 2 sub-divisions and carry 14 marks.

COURSE LEVEL ASSESSMENT QUESTIONS

Course Outcome 1 (CO1) Analyze various machining process and calculate relevant quantities such us velocities, forces and powers.

1. List out various types of Lathe attachment explain
2. Explain the working principle of slotter
3. In a verniercalliper, the main scale reads in millimetres with a least count of 0.1 mm.Ten divisions on the vernier correspond to nine divisions of the main scale. Determine the

leastcount of the calliper.

4. A shaft is manufactured within the specified limits of 30.02 and 29.98 mm. Find the high and low limits of the bush to give a maximum clearance of 0.10 mm and minimum clearance of 0.02 mm.
5. What is the difference between rough grinding and precision grinding?

Course Outcome 2 (CO2): Analysis of the tool nomenclature with surface roughness obtainable in each machining processes.

1. Define the terms 'Cutting speed', 'feed' and 'depth of cut'?
2. How are abrasives selected for grinding operation?
3. Why a coolant used in grinding work?
4. How the grinding wheel is selected for a particular job?
5. Describe the nomenclature of hob.
6. Discuss the significant machining parameters for shaping machine.

Course Outcome 3 (CO3): Understand the limitations of various machining process with regard to shape formation and surface texture.

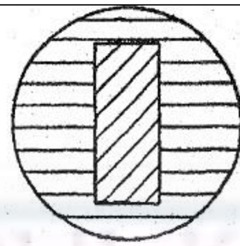
1. What is the difference between drilling, boring and reaming?
2. Explain any three thread production processes.
3. Explain counter sinking and trepanning.
4. Explain different types of gear hobbing machines.
5. Explain planning of guide gibs and slotting of keyways.

Course Outcome 4 (CO4): Students will demonstrate knowledge of the underlying principles of measurement, as they relate to mechanical measurement, electronic instrumentation, and thermal effects.

1. Describe the GO and NOGO gauge design procedure with neat sketch.
2. Design general type GO and NO GO gauges for a 40H7/d8 fit. 40 mm lies in the diameter range 30 to 50. Show graphically the disposition of gauge tolerance zones relative to the work tolerance zones. Standard tolerance for IT7 is 16i and IT8 is 25i, where 'I' is the standard tolerance unit. The upper deviation for 'd' shaft is $-16\,D^{0.44}$.
3. A 50 mm long pin having diameter 20 $\pm$ 0.02 mm, will be electroplated for a thickness of 50 $\pm$ 5 μm. Estimate the size of a GO limit gauge, neglecting the gauge to tolerances.

Course Outcome 5 (CO5): Get an exposure to advanced measuring devices and machine tool metrology.

1. Is assessment length greater/lesser than transverse length in surface roughness measurements? Why?
2. A surface tested under an optical flat using interferometer shows the following interference fringe pattern. Intercept the nature of the surface.



3. What are difference between Rt and Rz with neat sketches
4. How are CMM classified based on their construction? With neat sketches explain the merits and applications any one of them.

MODEL QUESTION PAPER

FIFTH SEMESTER MECHANICAL ENGINEERING

MACHINE TOOLS AND METROLOGY-MET 307

Max. Marks: 100 Duration: 3 Hours
Part – A

Answer all questions.
Answer all questions, each question carries 3 marks

1. What is trepanning? Explain with sketch.
2. What are the use of face plate and angle plate in a lathe?
3. With a sketch, show rake angle of milling cutter and chip breaker.
4. What s the difference between grinding wheel dressing and truing
5. What is the principle of Gear shaping? Explain.
6. Write note on gear errors.
7. Differentiate between precision and accuracy.
8. Explain the process of wringing of slip gauges.
9. Write the importance of cut off length in surface roughness measurement
10. Explain the principle of measurement by light wave interference method.

PART –B

Answer one full question from each module.

MODULE – 1

11. a. What are the attachments used on a center lathe and what purpose do they serve? (7 marks).

b.Draw a drillsignature, name the important angles and explain their each functionand explain plaining of guide gibs(7 marks).

12. Draw sketch of a crank shaper, mark the important parts and explain their functions. Explain how quick return mechanism works. (14 marks).

MODULE – 2

13. a. Explain the principle of working of centreless grinding machine. (7 marks).

b. What are ‘Through Feed’, ‘In Feed’, and ‘End Feed’ in centreless grinding operations? (7 marks).

14. a**.** Explain in detail with neat sketches of a) Slot and groove milling, b) profile milling c) thread milling(7 marks).

b**.** What is the need of better surface finish and how honing, lapping and burnishing process are different in its features and roughness obtainable, explain with sketches. (7 marks).

MODULE – 3

15. Why gear finishing processes are required? Write down the advantages and limitations of gear shaving and gear lapping process with neat sketches. (14 marks).

16 Describe the different methods of manufacturing various types of gears i. Preforming ii. Producing gear teeth by machining iii. Finishing gear teeth (14 marks).

MODULE – 4

17 Discuss all the principles of achieving accuracy. Explain all types of errors. (14 marks).

18. Determine limit dimensions for a clearance fit between mating parts of diameter 40 mm, providing a minimum clearance of 0.10 mm with a tolerance on the hole equal to 0.025mm and on shaft 0.05mm using both systems(14 marks).

MODULE – 5

19 a) Define the following terms in surface texture measurements: -
(i) Primary Texture.(ii) Secondary Texture.(iii) Lay(iv) Sampling Length.(7 marks).

b) Describe the method of evaluating roughness using(i) Peak to valley high method. (ii) C.L.A. method. (7 marks).

20 a) Discuss the different types of probes used in CMM (7 marks).

b.) Explain the various steps in machine vision system (7 marks).

SYLLABUS

MODULE – 1

General purpose machine tools – types and classification of machine tools –types and classification of lathe – methods of holding work and tool –lathe accessories and attachments –lathe operations -tool room lathe – duplicate lathe –capstan and turret lathe –horizontal and vertical-single spindle and multi spindle screw machines - Shaping, Plaining and Slotting machines – Work holding devices-types of operations - surface roughness obtainable indexing - Drilling and boring Machines – -Drill bit nomenclature- cutting forces in drilling – tool and work holding devices-boring tools and reamers.

MODULE – II

Milling tool nomenclature - Cutting forces in milling – Calculation of machining time- Indexing head Different indexing methods -Grinding, honing and lapping – types of grinding machines-operations: cutting forces in grinding -Grinding mechanisms – Grinding wheels - surface roughness obtainable in grinding, honing and lapping.

MODULE – III

Broaching machines –different machines – cutter for broaching – broaching processes – internal external broaching - Gear cutting –methods in gear production – form cutters –gear generating machines – gear hobbing machines – gear broaching -Bevel gear cutting –worm gear cutting –gear finishing.

MODULE – IV

Metrology –principles of achieving accuracy -Theory of tolerances and allowances –system of limits and fits – types of fits – interchangeability and selective assembly –standards of measurements- Gauges – classification of gauges –principle of gauge tolerance –wear allowance.

MODULE – V

Instruments for checking straightness, flatness and squareness–pneumatic gauging –precision gauging – automatic gauging for inspection-Optical measuring instruments –Comparators –Measurements of surface roughness –- gauging and measurements of screw and gears- Advanced measuring devices – Laser interferometers- Coordinate Measuring Machine (CMM).

Text Books

1. Chapman W. A. J., Workshop Technology, Viva books (P) Ltd
2. HMT, Production Technology, Tata McGraw-Hill
3. Engineering Metrology and Measurements, N.V. Raghavendra, l. Krishnamurthy, oxford university press
4. Galyer J.F.W., Schotbolt C.R., Metrology for Engineers, ELBS.

Reference

1. Acharkan. N., Machine Tool Design Vol. 1 to 4, MIR Publication
2. Chernov, Machine Tools, MIR Publication.
3. HajraChoudary, Elements of workshop technology, Vol I & II, Media Publishers.
4. ASME, Hand book of Industrial Metrology.
5. Hume K. J., Engineering Metrology, Macdonald &Co. Ltd.
6. Sharp K.W.B., Practical Engineering Metrology, Sir Isaac Pitman & Sons Ltd.

COURSE CONTENT AND LECTURE SCHEDULES.

Module	TOPIC	No.of hours	Course outcomes
1.1	General purpose machine tools – types and classification of machine tools –Lathe – types and classification of lathe – specification for a lathe –	1	CO3
	Feed,depth of cut, speed-methods of holding work and tool – lathe accessories and attachments –lathe operations and tools used for each operations -	3	CO1
1.2	Brief study of the machine and the nature and type of jobs handled by the following: - tool room lathe – duplicate lathe – capstan and turret lathe –horizontal and vertical-single spindle and multi spindle screw machines.	3	CO2
1.3	Shaping, Plaining and Slotting machines – Types and specifications – quick return motion –hydraulic feed and its advantages - automatic feed – speed,feed and depth of cut– Work holding devices-types of operations and examples of work done- surface roughness obtainable indexing (Self learning portion, discretion of faculty, fundamentals to be explained in the class)	1	CO3
1.4	Drilling and boring Machines – Types and specifications – Brief descriptions about the machines and nature, types of job	1	CO3

	handled by each of them.		
1.5	-Drill bit nomenclature- cutting forces in drilling – tool and work holding devices-boring tools and reamers.	1	CO2
2.1	Milling machines – types and specifications- Milling operations and types of milling cutters used for each.	1	CO3
2.2	- Milling tool nomenclature - Cutting forces in milling – Calculation of machining time- Indexing head and its use -	1	CO1 CO3
2.3	Different indexing methods - Differential indexing (Self learning portion discretion of faculty, fundamentals to be explained in the class)	1	
2.4	Grinding, honing and lapping – types of grinding machines-operations: cylindrical, surface and center less grinding – internal grinding, tool and cutter grinding - cutting forces in grinding	3	CO1 CO3
2.5	Grinding mechanisms – Grinding wheels: Specification – types of abrasives, grain size -Types of bond, grade, and structure – Marking system of grinding wheels – Selection of grinding wheels –need of better surface finish; surface roughness obtainable in grinding, honing, lapping and burnishing; Surface roughness comparisons between different conventional metal cutting processes.	3	CO3
3.1	Broaching machines –different machines – cutter for broaching – different broaching processes – internal external broaching.	3	CO3
3.2	Gear cutting –methods used in gear production – form cutters – gear generating machines – gear hobbing machines – gear broaching.	3	CO3
3.3	Bevel gear cutting – straight and spiral gears-worm gear cutting –gear finishing operations.	3	CO3
4.1	Metrology –principles of achieving accuracy –economic machining accuracy – precision Vs accuracy - errors- standards of measurements-	2	CO 4
4.2	Theory of tolerances and allowances –system of limits and fits – types of fits – interchangeability and selective assembly – Taylor’s Principle-	4	CO 4
4.3	Gauges – classification of gauges- plug, ring, taper angle, slip and snap gauges –feeler gauges-dial indicator –principle of gauge tolerance –wear allowance-gauge materials.	4	CO 4 CO 5
5.1	Instruments for checking straightness, angle, flatness and squareness of guiding surface(Self learning portion, discretion of faculty, fundamentals to be explained in the class). – pneumatic gauging –precision gauging –automatic gauging for inspection.	2	CO 4 CO 5

5.2	Optical measuring instruments, baisc principle – interferometer-optical flat –optical tool makers' microscope-autocollimator.	2	CO 5
5.3	Comparators – mechanical, optical, pneumatic, electric and electronic comparators. (Self learning portion, discretion of faculty, fundamentals to be explained in the class).	1	CO 4
5.4	Measurements of surface roughness – elements of roughness – symbols specifying –instruments and for measuring surface roughness-	1	CO 4
	Measurements of screw: terminology, measurement of screw thread elements-measurement of gears: terminology, errors in spur gears, measurement of gear elements.	2	
5.5	Advanced measuring devices – Laser interferometers-Coordinate Measuring Machine (CMM)	1	CO 5

CODE MEL331	COURSE NAME: MACHINE TOOLS LAB II	CATEGORY	L	T	P	CREDIT
		PCC	0	0	3	2

Preamble:

1. To learn the measurement of bores by internal micrometers, bore indicators, indirect methods etc.
2. To learn the measurement of the Angle and taper by Bevel protractor, Sine bars, indirect methods etc.
3. Allow to study the various limits, fits and tolerances adopted in the production drawings.
4. To learn to measure straightness, flatness, roundness, profile, screw threads and gear teeth.
5. To learn, to prepare programs for CNC machines and measurements in CMM.

Course Outcomes - At the end of the course students will be able to

CO 1

Apply the procedures to measure length, angles, width, depth, bore diameters, internal and external tapers, tool angles, and surface roughness by using different instruments and by different indirect methods.

CO 2

Determine limits and fits and allocate tolerances for machine components

CO 3

CNC programming and to use coordinate measuring machine to record measurements of complex profiles with high sensitivity.

CO 4

Use effective methods of measuring straightness, Squareness, flatness, roundness, profile, screw threads and gear teeth.

CO 5

Securing knowledge of manufacturing components within the tolerance limit and surface roughness according to given drawings using various machine tools.

Mapping of course outcomes with program outcomes (Minimum requirements)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	-	-	-	-	-	-	-	-	-	-	-
CO 2	-	-	3	-	-	-	-	-	-	-	-	-
CO 3	-	-		3	-	-	-	-	-	-	-	-
CO 4	-	3	-	-	-	-	-	-	-	-	-	-
CO 5	-	-	-	-	3	-	-	-	-	-	-	-

Assessment Pattern

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	75	75	2.5 hours

Continuous Internal Evaluation Pattern:

Attendance : 15 marks
Continuous Assessment : 30 marks
Internal Test (Immediately before the second series test) : 30 marks

End Semester Examination Pattern: The following guidelines should be followed regarding award of marks
(a) Preliminary work : 15 Marks
(b) Implementing the work/Conducting the experiment : 10 Marks
(c) Performance, result and inference (usage of equipments and trouble shooting) : 25 Marks
(d) Viva voce : 20 marks
(e) Record : 5 Marks

General instructions:
Practical examination is to be conducted immediately after the second series test covering entire syllabus given below. Evaluation is a serious process that is to be conducted under the equal responsibility of both the internal and external examiners. The number of candidates evaluated per day should not exceed 20. Students shall be allowed for the University examination only on submitting the duly certified record. The external examiner shall endorse the record.

SYLLABUS

Experiments on Grinding machine – Programming and experiments on CNC machines-Uncertainty in metrology and measurement standards - Errors and their impact on the calculation of uncertainties - Measurement types and instrument selection - Geometric features of parts - Measuring straightness, squareness, flatness, roundness, and profile -Screw threads and gear teeth, optical contour projectors - Gage measurement - Surface texture and roughness measurement – flaw detection - Coordinate measuring machine - Modern measuring instruments and machines.

Reference books

1. Yoram Koren, Numerical Control of Machine Tools, McGraw-Hill.
2. Shotbolt C.R. and Gayler J.F.W, Metrology for Engineers, 5th edition, ELBS, London.
3. Sharp K.W.B. and Hume, Practical Engineering Metrology, Sir Isaac Pitman and sons Ltd,

London.

4. Collett, C.V. and Hope, A.D, Engineering Measurements, Second edition, ELBS/Longman

Experiments	List of Experiments	Course outcomes	No. of hours
1	**Programming and experiment on CNC machines** Study and preparation of programme, simulation and exercise on CNC lathe:-turning, step turning, taper turning, thread cutting, ball and cup turning etc.	CO 3	3
2	Study and preparation of programme, simulation and exercise on CNC milling machine: - surface milling, pocket milling, contour milling etc.		3
3	**Experiment on Grinding machine** Exercise on surface grinding, cylindrical grinding and tool grinding etc. Measurement of cutting forces and roughness in grinding process and correlate with varying input parameters.	CO 1 CO 5	3
4	**Basics for mechanical measurements** Calibration of vernier caliper, micrometer and dial gauge. Determination of dimensions of given specimen using vernier caliper, micrometer, height gauge, bore dial gauge etc. Determination of dimensions of a rectangular, square, cylindrical specimens using slip gauges and comparing with height gauge/vernier caliper etc **Experiments on Limits, Fits and Tolerance** Determine the class of fits between given shaft and hole. etc	CO 1 CO 2	3
5	**Experiments on Repeatability and Reproducibility** Study and analysis of repeatability and reproducibility of given batch of steel balls. etc.	CO 1 CO 2	3
6	**Linear measurements** Study of different linear measuring instruments etc. Calibration of LVDT using slip gauges	CO 1 CO 5	3

7	**Straightness error measurement** Study of different straightness error measuring instruments – basic principle of auto collimator, spirit level and laser interferometer. Measurement of straightness error of a CI surface plate using auto collimator and comparing with sprit level. Laser interferometer used to determine straightness error To check straightness error of a straight edge by the wedge method using slip gauges.	CO 4	3
8	**Angle measurements** Angular measurements using bevel protractor, combination sets, clinometers, angle dekkor etc. Measurement of angle and width of a V-block and comparing with combination sets. Measurement of angle using sine bar of different samples. Determination of angle and taper of a taper plug gauge	CO 1	3
9	**Out of roundness measurement** Study of different methods used for measuring out of roundness Measurement of out of roundness using form measuring instrument Measurement of out of roundness using V-block and dial gauge Measurement of out of roundness using bench centre and dial gauge etc.	CO 4	3
10	**Screw thread measurement** Measurement of screw thread parameters using two wire and three wire method. Measurement of screw thread parameters using tool maker's microscope etc. Measurement of screw thread parameters using thread ring gage, thread plug gage, thread snap gage, screw thread micrometer, optical comparator etc.	CO 4	3
11	**Bore measurement** Measurement of a bore by two ball method. Measurement of a bore by four ball method. Bore measurement using slip gauges and rollers.	CO 1	3

	Bore measurement using bore dial gauge etc.		
12	**Gear metrology** Study of types of gears – gear terminology – gear errors - Profile Projector. Measurement of profile error and gear parameters using profile projector etc. **Use of Comparators** Exercise on comparators: mechanical, optical, pneumatic and electronic comparators.	CO 4	3
13	**Use of Tool maker's microscope** Study of tool maker's microscope – use at shop floor applications. Measurement of gear tooth parameters using tool maker's microscope. Measurement of different angles of single point cutting tool using tool maker's microscope.	CO 1	3
14	**Surface roughness measurement** Measurement of surface roughness using surface profilometer /roughness measuring machine of turned, milled, grounded, lapped and glass etc specimens.	CO 1	3
15	**Squareness measurement** Determination of squareness of a trisquare using angle plate and slip gauges etc.	CO 1	3
16	**Flatness measurement** Study of optical flat and variation of fringe patterns for different surfaces. Determination of parallelism error between micrometer faces etc. Compare given surface using optical flat with interpretation chart.	CO 4	3
17	**Vibration measurement** Measurement of displacement, velocity and acceleration of vibration.	CO 5	3

18	**Use of Pneumatic comparator** Checking the limits of dimensional tolerances using pneumatic comparator Calibration using air plug gauge etc	CO 5	3
19	**Rotation measurement** Determination of rpm using tachometer, optical tachometer and stroboscope, etc. **Flaw detection** Study and use of ultrasonic flaw detector.	CO 5	3
20	**Other measurements** Study and making measurements with precision vernier calipers, dial calipers, point micrometer spline micrometer, wire groove micrometer, depth micrometer, V- anvil micrometers, depth gear tooth micrometer, thread micrometer, disc micrometer, thread pitch gauge, vernier height gauge, feeler gauge, three pin micrometer, depth gauge, pitch gauge, thickness gauge, radius gauge, hole test etc. Analysis of automobile exhaust gas and flue gas. Use of feeler gauge to determine the gap of spark plug. Any other modern measuring instruments CMM, EDM, Wire cut EDM,USM etc	CO 5	3

A minimum of 12 sets of experiments are mandatory out of total 20 experiments but both experiments mentioned for programming and experiments on CNC machines are mandatory.

Besides to the skill development in performing the work, oral examination should be conducted during end semester examination.

The student's assessment, continuous evaluation, record bonafides, awarding of sessional marks, oral examination etc. should be carried out by the assistant professor or above.

CODE MEL333	COURSE NAME: THERMAL ENGINEERING LAB 1	CATEGORY	L	T	P	CREDIT
		PCC	0	0	3	2

Preamble: The course is intended to impart basic understanding on the working of internal combustion engines. This includes various performance tests on internal combustion engines as well as makes the students familiar with the evaluation of fuel properties such as viscosity, flash and fire points, calorific value etc. which are key to any performance test.

Prerequisite: Should have undergone a course on Thermal Engineering with emphasis on IC engines

Course Outcomes: After completion of the course the student will be able to

CO 1	**Measure thermo-physical properties of solid, liquid and gaseous fuels**
CO 2	**Identify various systems and subsystems of Diesel and petrol engines**
CO 3	**Analyse the performance characteristics of internal combustion engines**
CO 4	**Investigate the emission characteristics of exhaust gases from IC Engines**
CO 5	**Interpret the performance characteristics of air compressors / blowers**

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	**3**		2	3			2		3	2		2
CO 2	**3**		2	3			2		3	2		2
CO 3	**3**		2	3			2		3	2		2
CO 4	**3**		2	3			2		3	2		2
CO 5	**3**		2	3			2		3	2		2

Assessment Pattern

Mark distribution

Total Marks	**CIE**	**ESE**	**ESE Duration**
150	75	75	2.5 hours

Continuous Internal Evaluation Pattern:

Attendance	:	15 marks
Continuous Assessment	:	30 marks
Internal Test (Immediately before the second series test)	:	30 marks

End Semester Examination Pattern: The following guidelines should be followed regarding award of marks

(a) Preliminary work : 15 Marks
(b) Implementing the work/Conducting the experiment : 10 Marks
(c) Performance, result and inference (usage of equipments and trouble shooting) : 25 Marks
(d) Viva voce : 20 marks
(e) Record : 5 Marks

General instructions:

Practical examination is to be conducted immediately after the second series test covering entire syllabus given below. Evaluation is a serious process that is to be conducted under the equal responsibility of both the internal and external examiners. The number of candidates evaluated per day should not exceed 20. Students shall be allowed for the University examination only on submitting the duly certified record. The external examiner shall endorse the record.

List of Exercises/Experiments: (Lab experiments may be given considering 12 sessions of 3 hours each. Minimum 12 experiments to be performed.)

1. Determination of flash and fire points of petroleum fuels and oils
2. Determination of viscosity of lubricating oils and fuels and its variation with temperature
3. Determination of calorific value of solid and liquid fuels- Bomb Calorimeter
4. Determination of calorific value of gaseous fuels –Gas Calorimeter
5. Familiarisation of various systems and subsystems of petrol engine / MPFI engine
6. Familiarisation of various systems and parts of Diesel engine / Turbocharged engine
7. Performance test on petrol engines / MPFI engine
8. Performance test on Diesel engines / Turbocharged engine
9. Heat Balance test on petrol/Diesel engines
10. Determination volumetric efficiency and Air-fuel ratio of IC engines
11. Cooling curve of IC engines
12. Valve timing diagram of IC engines
13. Economic speed test on IC engines
14. Retardation test on IC engines
15. Morse test on petrol engine
16. Experiment to find flame temperature of premixed flames at different equivalence ratios and temperature of diffusion flames at different fuel flow rates.
17. Analysis of automobile exhaust gas and flue gas using exhaust gas analyser.
18. .Performance test on reciprocating compressor
19. Performance test on rotary compressor/blower

Reference Books

1. J.B.Heywood, I.C engine fundamentals, McGraw-Hill, 2017
2. V. Ganesan, Fundamentals of IC engines, Tata McGraw-Hill, 2017
3. Stephen R Turns, An Introduction to Combustion: Concepts and Applications, McGraw-Hill, 2017

SEMESTER V

MINOR

CODE MET381	Course Name DYNAMICS OF MACHINES	CATEGORY	L	T	P	CREDIT
		VAC	3	1	0	4

Preamble: This course mainly covers the topics namely force analysis of engines, turning moment diagrams, balancing of rotating and reciprocating machines and stability analysis of vehicles. Analysis of free and forced vibration of single degree of freedom systems are included.

Prerequisite: EST100 Engineering Mechanics

Course Outcomes: After the completion of the course the student will be able to:

CO 1	Analyse forces in a four bar mechanism
CO 2	Draw turning moment diagrams for a steam engines and internal combustion engines.
CO 3	Calculate the unbalanced masses in rotating and reciprocating machines.
CO 4	Calculate gyroscopic couple and do stability analysis of vehicles
CO 5	Analyse free and forced vibrations of single degree of freedom systems

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3	2									
CO 2	3	3	2									
CO 3	3	3	2									
CO 4	3	3	2									
CO 5	3	3	2									

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	10
Understand	20	20	20
Apply	20	20	70
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance	: 10 marks
Continuous Assessment Test (2 numbers)	: 25 marks
Assignment/Quiz/Course project	: 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Explain D' Alembert's principle.
2. Determine analytically the forces such as piston effort, force in the connecting rod and side thrust on the cylinder walls of a reciprocating engine.
3. Draw the force polygon of a four bar mechanism.
4. Use virtual work and determine the external torque required to be applied in the case of a slider-crank engine.

Course Outcome 2 (CO2)

1. Define coefficient of fluctuation of energy
2. Draw turning moment diagrams for single cylinder double stroke steam engine.
3. Find the centrifugal stress in a flywheel for a given tangential speed.
4. Determine the maximum fluctuation of energy for a multi cylinder engine.

Course Outcome 3 (CO3)

1. Distinguish between static balancing and dynamic balancing.
2. What is single plane balancing? Explain.
3. Draw the force polygon and couple polygon when several masses rotate in different (parallel) planes.
4. Explain i) hammer blow ii) variation in tractive effort and iii) swaying couple in locomotives
5. What do you mean by primary and secondary unbalanced forces?

Course Outcome 4 (CO4):

1. Derive an expression relating the stress in a flywheel and its linear speed.
2. Describe with neat sketches the effects of gyroscopic couple on pitching, rolling and steering of a ship
3. Find an expression for the angle of heel for a two wheeler

4. Define coefficient of fluctuation of energy and maximum fluctuation of energy.

Course Outcome 5 (CO5):

1. Explain the energy method and Newton's method to determine the natural frequencies of a single degree of freedom system.
2. Derive an expression for the logarithmic decrement.
3. Find the forced response of a damped single degree of freedom vibrating system subjected to a harmonic excitation.
4. Distinguish between motion transmissibility and force transmissibility.
5. What is whirling? Derive an expression for the critical speed of a shaft.

MODEL QUESTION PAPER

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

V SEMESTER BTECH DEGREE EXAMINATION

MET381: DYNAMICS OF MACHINES

Maximum:100 Marks Duration:3 hours

PART A

Answer all questions, each question carries 3 marks

1. Explain virtual work method of force analysis of a four-bar mechanism.
2. What is meant by equivalent dynamic systems?
3. Define coefficient of fluctuation of energy and coefficient of fluctuation of speed.
4. Why flywheels are required?
5. Distinguish between static and dynamic balancing.
6. What is meant by partial balancing? List the effects of partial balancing.
7. Describe the effect of gyroscopic couple on the stability of a two-wheeler while negotiating a curve.
8. Define coefficient of fluctuation of speed and coefficient of fluctuation of energy.
9. Explain the energy method of obtaining the natural frequency of a single degree of freedom vibrating system.
10. Explain transmissibility. (10×3=30Marks)

PART B

Answer one full question from each module

MODULE 1

11. a) A slider crank mechanism of crank radius 60 mm and connecting rod length 240 mm is acted upon by 2 kN gas force at its piston. Calculate the torque to be applied on the crank to make the mechanism in static equilibrium when the crank makes 60° with the line of stroke. Use graphical method. (9 marks)

    b) Distinguish between static and dynamic force analyses. (5 marks)

12.a)) State and explain D' Alembert's principle. (4 marks)

b) The ratio of connecting rod length to crank length of a vertical gasoline engine is 4. The engine bore and stroke are 8 cm and 10 cm respectively. The mass of the reciprocating parts is 1 kg. The gas pressure on the piston is 6 bar, when it has moved 40° from the inner dead centre during the power stroke. Determine:

i. net load on the piston

ii. net load on the gudgeon pin and the crank pin

iii. thrust on the cylinder walls

iv. thrust on the crank bearing

MODULE 2

13. a) Derive an expression for the centrifugal stress in a flywheel as a function of the tangential velocity. (5 marks)

b) A machine is coupled to a two stroke engine which produces a torque of 800+180 sin 3θ Nm where θ is the crank angle. The mean engine speed is 400 rpm. The flywheel and the other rotating parts attached to the engine have a mass of 350 kg at a radius of gyration of220 mm. Calculate: i) the power of the engine and ii) the total fluctuation of speed of the flywheel. (9 marks)

14.. a) Draw the turning moment diagram for a 4 stroke diesel engine. (4 marks)

b) The turning moment diagram for a multi cylinder engine has been draw to a scale of 1 cm to 5000 Nm torque and 1 cm to 60° respectively. The intercepted areas between output torque curve and mean resistance line taken in order from one end are: -0.3; +4.1; -2.8; +3.2; -3.3; +2.5; -3.6; +2.8; -2.6 square cm when the engine is running at 800 rpm. The engine has a stroke of 30 cm and the fluctuation of speed is not to exceed 2% of the mean speed. Determine a suitable diameter and cross-section of the flywheel rim for a limiting value of shaft centrifugal stress of 280 x 10^5 N/m^2. The material density may be assumed as 7.2 g/cm^3 . Assume thickness of the rim to be ¼ of the width.

(10 marks)

MODULE 3

15. a) Four masses 200 kg, 300 kg, 240 kg and 260 kg with radii of rotation are positioned at 20 cm, 15 cm, 25 cm and 30 cm respectively. Their corresponding angular positions with respect to mass 200 kg are 45°, 75° and 135°. Find the

magnitude and position of the balancing mass required if the radius of rotation is 20 cm. (10 marks)

b) Dynamically balanced system is statically balanced, but not vice versa. Give your comments. (4 marks)

16. a) Describe the effects of partial balancing of reciprocating engines. (9 marks)

b) Four masses are attached to shaft at planes A, B, C and D at equal radii. The distance of planes B, C and D from A are 50 cm, 60 cm and 130 cm respectively. The masses at A, B and C are 60 kg, 55 kg and 80 kg respectively. If the system is in complete balance, determine the mass at D and the position of masses B, C and D with respect to A.

(10 marks)

MODULE 4

17. a) Explain spin vector, precession vector, gyroscopic applied torque vector and gyroscopic reactive torque vector. (4 marks)

b) Explain the effects of gyroscopic couple on the stability of a four wheeler while it negotiates a curve. (10 marks)

18. a) What is the function of a flywheel? (4 marks)

b) Determine the maximum and minimum speeds of a flywheel of mass 25 kg and radius of gyration of 10 cm when the fluctuation of energy is 54.5 Nm. The mean speed of the engine is 1000 rpm. (10 marks)

MODULE 5

19. a) A machine of mass 1000 kg is acted upon by an external force of 2450 N at a speed of 1500 rpm. To reduce the effect, vibration isolators made of rubber having a static deflection of 2 mm under the machine load and an estimated damping factor of 0.2 are used. Determine the following:

i. Force transmitted to the foundation
ii. Amplitude of vibration of machine
iii. Phase lag between the transmitted force and the displacement of mass.

(10 marks)

b) Distinguish between motion transmissibility and displacement transmissibility.

(5 marks)

20.a)) A damped spring mass system has mass 3 kg, stiffness 100 N/m and damping coefficient 3 Ns/m. Determine the following:

i. Damping ratio
ii. Damped natural frequency
iii. Logarithmic decrement
iv. Ratio of two successive amplitudes (8 marks)

b) Describe briefly Newton's method and energy method used for obtaining the natural frequencies. (6 marks)

Syllabus

Module 1

Static and dynamic force analysis of mechanisms (four bar linkages only)-graphical method-virtual work method -D'Alembert's principle-equivalent dynamic systems-reciprocating engine force analysis

Module 2

Flywheels-turning moment diagrams for steam engines-four stroke internal combustion engine and multi cylinder engines-coefficient of fluctuation of speed-coefficient of fluctuation of energy-design of flywheels.

Module 3

Balancing: static balancing-dynamic balancing-balancing of several masses revolving in a single plane-several masses in different parallel planes-balancing of single cylinder reciprocating engines-partial balancing and its effects-balancing of multi cylinder inline engines

Module 4

Gyroscopic couple-effects on the stability of automobiles-two wheeler and four wheeler, stability of ships and air crafts-Flywheels-turning moment diagrams-coefficient of fluctuation of energy, coefficient of fluctuation of speed

Module 5

Vibration-free vibration of single degree of freedom systems-equation of motion-Newton's method-energy method-natural frequency-undamped and damped systems-logarithmic decrement-forced vibration-response of SDOF systems to harmonic excitation-whirling of shaft-vibration absorber-transmissibility

Text Books

1. Ballaney, P. L. Theory of machines and mechanisms. Khanna Publishers, 2010.

2. Rattan S S, Theory of Machines, Tata McGraw-Hill Education, 2005.

Reference Books

1. Charles E Wilson and J Peter Sadler, Kinematics and Dynamics of Machinery, Tata McGraw-Hill Education, 2008.

2. Amithabha Ghosh and Asok Kumar Malik, Theory of Mechanisms and Machines, East West Press, 2011

3. Thomas Bevan, Theory of Machines, Pearson, 2013.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1		
1.1	Static analysis of mechanisms-graphical method-four bar mechanisms	3
1.2	Virtual work method -D'Alembert's principle-equivalent dynamic systems	3
1.3	Reciprocating engine force analysis	2
2		
2.1	Flywheels, turning moment diagrams-steam engines-four stroke internal combustion engines and multi cylinder engines	4
2.2	Multi cylinder engine-coefficient of fluctuation of speed-coefficient of fluctuation of energy-design of flywheels	4
3		
3.1	Static and dynamic balancing- balancing of several masses in a single plane-force polygon	3
3.2	Balancing of several masses in parallel planes-couple polygon	3
3.3	Balancing of reciprocating masses-effects of partial balancing	2
3.4	Balancing of multi cylinder in-line engines	2
4		
4.1	Gyroscopic couple-introduction-spin, precession and applied couple vectors	2
4.2	Effects of gyroscopic couple on the stability of two wheeler and four wheeler	2
4.3	Effects on the stability of sea vessels and air crafts	3
4.4	Flywheels-turning moment diagrams-coefficient of fluctuation of energy, coefficient of fluctuation of speed	3
5		
5.1	Vibration-free vibration of single degree of freedom systems-equation of motion-Newton's method-energy method-natural frequency	3
5.2	Damped systems-logarithmic decrement-forced vibration-response of SDOF systems to harmonic excitation	3
5.3	Whirling of shaft-vibration absorber- transmissibility	3

CODE MET383	COURSE NAME THERMAL SCIENCE AND ENGINEERING	CATEGORY	L	T	P	CREDIT
		VAC	3	1	0	4

Preamble: This course involve the application of principles studied in thermodynamics to different energy conversion systems like steam turbine, steam powerplant, IC engines and refrigeration systems. This course also covers the methods for improving and evaluating the performance of different energy conversion systems. This course also helps to understand the combustion phenomenon in IC engines.

Prerequisite: MET284 Thermodynamics (Minor)

Course Outcomes: After the completion of the course the student will be able to

CO 1	Explain the working of steam power cycle and related components
CO 2	Discuss the working of steam turbines and methods for evaluating the performance
CO 3	Illustrate the performance testing and evaluation of IC engines
CO 4	Explain the combustion phenomenon and pollution in IC engines
CO 5	Discuss the principles of refrigeration and air-conditioning and basic design considerations

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	**3**	3	2									
CO 2	**3**	3	2									
CO 3	**3**	3	2									
CO 4	**3**	3	2									
CO 5	**3**	3	2									

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	10
Understand	20	20	20
Apply	20	20	70
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. In a reheat Rankine cycle, steam at a pressure of 40 bar and 300°C is expanded through a turbine to a pressure of 4 bar. It is then heated at a constant pressure to 300° C and then expanded to 0.1 bar. Estimate the work done per kg of steam flowing through the turbine, the amount of heat supplied during the reheat process and the cycle efficiency. Neglect pump work.
2. Explain the term boiler mountings and accessories
3. With the help of a figure explain the working of Babcock and Wilcox boiler.

Course Outcome 2 (CO2):

1. In an impulse steam turbine, steam issues from the nozzle with a velocity of 1200 m/s. The nozzle angle is 20^{o} and the mean blade velocity is 400 m/s. The inlet and outlet blade angles are equal. The blade velocity coefficient is 0.8. The mass of steam flowing through the turbine per hour is 950 kg. Calculate: (i) Blade angles. (ii) Relative velocity of steam entering the blades (iii) Tangential force on the blades. (iv) Power developed. (v) Blade efficiency.
2. Derive the conditions for maximum efficiency of a Parsons reaction turbine.
3. Discuss the means of improving the performance of a steam turbine.

Course Outcome 3(CO3):

1. A 4-cylinder four stroke petrol engine is working based on the following data: Air-fuel ratio by weight = 15:1, calorific value of the fuel = 45000 kJ/kg, mechanical efficiency = 80 %, air- standard efficiency = 54 %, relative efficiency = 70 %, volumetric efficiency = 75 %, stroke/bore ratio = 1.25, suction conditions = 1 bar and 30 ^{o}C, r.p.m. = 2500, brake power = 70 kW. Calculate: (i) Compression ratio. (ii) Indicated thermal efficiency. (iii) Brake specific fuel consumption. (iv) Bore and stroke.
2. Discuss the working of a rotary engine and its merits and demerits over conventional IC engines.
3. Explain the performance testing of IC engines

Course Outcome 4 (CO4):

1. Explain equivalence ratio and its significance in IC engine combustion.
2. Explain different stages of SI engine combustion with the help of pressure-crank angle diagram.
3. Discuss detonation in SI engine, cause and effects and the engine variable influencing the same.

Course Outcome 5 (CO5):

1. Derive the expression for COP of an ideal air refrigeration cycle.
2. Explain the factors affecting human comfort
3. Write brief note on summer air conditioning

MODEL QUESTION PAPER

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

V SEMESTER BTECH DEGREE EXAMINATION

MET383: THERMAL SCIENCE AND ENGINEERING

Maximum: 100 Marks Duration:3 hours

Use of Steam tables, Refrigeration tables, Charts and Psychrometric chart is permitted.

PART A

Answer all questions, each question carries 3 marks

1. Explain Rankine cycle with help of a T-S diagram.
2. Differentiate between fire tube boiler and water tube boiler.
3. List the difference between throttle governing and nozzle governing.
4. Explain degree of reaction of a steam turbine.
5. Explain the term MEP
6. Explain the meaning of Specific Fuel
7. Explain the term Preignition
8. What do you meant by Octane number?
9. Why reversed Carnot cycle is practically impossible to execute?
10. Differentiate between specific humidity and relative humidity (10×3=30 Marks)

PART B

Answer one full question from each module

MODULE 1

11. a) Steam at a pressure of 15 bar and 250 ^{o}C is expanded through a turbine to a pressure of 4 bar. It is then reheated at constant pressure to initial temperature of 250 ^{o}C and finally expanded to condenser pressure of 0.1 bar. Calculate efficiency of the cycle. Pump work can be neglected. (8 marks)

    b) Explain in detail different boiler mountings and accessories. (6 marks)

12. a) With the help of a neat figure explain the working of a Benson boiler. What are its merits over other boilers? (8 marks)

b) With the help of T-s and p-h diagram explain the significance of binary vapour cycle. (6 marks)

MODULE 2

13. a) Derive the condition for maximum efficiency of a reaction turbine. (6 marks)

b) With the help of figures enumerate the difference between pressure compounding and velocity compounding of steam turbines. (8 marks)

14. a) What do you meant by reheat factor? List the parameters influencing the value of reheat factor. (4 marks)

b) In an impulse steam turbine, steam issues from the nozzle with a velocity of 1200 m/s. The nozzle angle is 20^o and the mean blade velocity is 400 m/s. The inlet and outlet blade angles are equal. The blade velocity coefficient is 0.8. The mass of steam flowing through the turbine per hour is 950 kg. Calculate: (i) Blade angles. (ii) Relative velocity of steam entering the blades. (iii) Tangential force on the blades. (iv) Power developed. (v) Blade efficiency. (10 marks)

MODULE 3

15. a) Discuss the terms a) Mechanical efficiency b) Volumetric Efficiency c) Thermal efficiency of an IC engine (9 marks)

b) Discuss the effect of variable specific heat in actual cycle of IC engines.(5 marks)

16. The following observations were recorded during a trial of a four stroke single cylinder diesel engine for a trial duration of 30 min. Fuel consumption is 4 liters, Calorific value of fuel 43 MJ/kg, specific gravity of the fuel = 0.8, average area of indicator diagram = 8.5 cm^2, length of indicator diagram = 8.5 cm, spring constant= 5.5 bar/cm, brake load = 150 kg, spring balance reading = 20 kg, effective brake wheel diameter = 1.5 m, speed = 200 rpm, cylinder diameter = 30 cm, stroke = 45 cm. Calculate i) indicate power ii) brake power iii) mechanical efficiency iv) specific fuel consumption in kg/kWh and v) indicated thermal efficiency. (14 marks)

MODULE 4

17. a) With the help of pressure-crank angle diagram explain different stages of CI engine combustion. (8 marks)

    b) Explain the phenomenon of detonation in SI engine based on autoignition theory. (6 marks)

18. With the help of figures compare different types of SI and CI engine combustion chambers. (14 marks)

MODULE 5

19. a) A freezer of 20 TR capacity has evaporator and condenser temperature of -30 ^{o}C and 25 ^{o}C respectively. The refrigerant R-12 is sub-cooled by 4 ^{o}C before entering the expansion valve and is superheated by 5 ^{o}C before entering the evaporator. If a six cylinder single acting compressor with stroke equal to bore running at 1000 rpm. is used. Determine i) COP ii) Theoretical piston displacement per minute iii) Theoretical bore and stroke. (9 marks)

    b) Derive an expression for COP of a Reversed Brayton cycle for air refrigeration system. (5 marks)

20. a) Explain the concept of summer air conditioning (10 marks)

    b) Define i) DPT ii) RH ii) SHF and iv) ADP. (4 marks)

Syllabus

Module 1

Steam engineering- Rankine cycle, Modified Rankine cycle, Relative efficiency, Improvement in steam cycles-Reheat, Regenerative and Binary vapour cycle. Steam Boilers: Types of boilers, Cochran boiler, Babcock and Wilcox boiler, Benson boiler, La Mont boiler, Boiler Mountings and Accessories.

Module 2

Steam turbines: classification, compounding of turbines-pressure velocity variation, velocity diagrams, work done, efficiency, condition for maximum efficiency, multistage turbines-condition line, stage efficiency. Steam turbine performance-reheat factor, degree of reaction, cycles with reheating and regenerative heating, governing of turbines.

Module 3

Actual cycle analysis of IC engines- Deviation of actual engine cycle from ideal cycle, Performance Testing of I C Engines- Indicator diagram, mean effective pressure. Torque, Engine power- BHP, IHP. Engine efficiency, mechanical efficiency, volumetric efficiency, thermal efficiency, relative efficiency and Specific fuel consumption.

Module 4

Combustion in I.C. Engines- Analysis of fuel combustion-A/F ratio, equivalence ratio, excess air. Combustion phenomena in S.I. engines; Ignition limits, stages of combustion in S.I. Engines, Ignition lag, velocity of flame propagation, auto ignition, detonation; effects of engine variables on detonation; theories of detonation, octane rating of fuels; pre-ignition; S.I. engine combustion chambers. Combustion in C.I. Engines; delay period; variables affecting delay period; knock in C.I. engines, Cetane rating; C.I. engine combustion chambers.

Module 5

Refrigeration– Reversed Carnot cycle, Air refrigeration system- Reversed Joule cycle. Vapour compression systems-simple cycle - representation on T- s and P- h Diagrams. Psychometric properties – specific humidity, relative humidity and degree of saturation, thermodynamic equations, enthalpy of moisture, DBT, WBT and DPT, psychrometers, psychometric chart. Comfort and industrial air conditioning, Comfort air conditioning-factors affecting human comfort, Effective temperature, comfort chart, Summer air conditioning

Text Books

1. Rudramoorthy , Thermal Engineering, McGraw Hill Education India, 2003.

2. R.K Rajput, Thermal Engineering, Laxmi publications, 2010.

3. Arora C. P, Refrigeration and Air-Conditioning, McGraw-Hill, 2008.

4. Arora S. C. and Domkundwar, Refrigeration and Air-Conditioning, Dhanpat Rai, 2010.

Reference Books

1. V. Ganesan, Fundamentals of IC engines, Tata McGraw-Hill, 2002.

2. J.B.Heywood, I.C engine fundamentals. McGraw-Hill, 2011.

3. Rathore, Thermal Engineering, McGraw Hill Education India, 2010.

4. Dossat. R. J, Principles of Refrigeration, Pearson Education India, 2002.

5. Stoecker W.F, Refrigeration and Air-Conditioning, McGraw-Hill Publishing Company, 2009.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1		
1.1	Steam engineering- Rankine cycle, Modified Rankine cycle, Relative efficiency, Improvement in steam cycles-Reheat, Regenerative and Binary vapor cycle.	4
1.2	Steam Boilers: Types of boilers, Cochran boiler, Babcock and Wilcox boiler, Benson boiler.	3
1.3	La Mont boiler, Boiler Mountings and Accessories.	2
2		
2.1	Steam turbines: classification, compounding of turbines-pressure velocity variation, velocity diagrams.	3
2.2	Work done, efficiency, condition for maximum efficiency, multistage turbines-condition line, stage efficiency.	3
2.3	Steam turbine performance-reheat factor, degree of reaction, cycles with reheating and regenerative heating, governing of turbines.	3
3		
3.1	Actual cycle analysis of IC engines- Deviation of actual engine cycle from ideal cycle	2
3.2	Performance Testing of I C Engines- Indicator diagram, mean effective pressure. Torque	2
3.3	Engine power- BHP, IHP. Engine efficiency, mechanical efficiency, volumetric efficiency, thermal efficiency	3
3.4	Relative efficiency, Specific fuel consumption.	2
4		
4.1	Combustion in I.C. Engines- Analysis of fuel combustion-A/F ratio, equivalence ratio, excess air.	1
4.2	Combustion phenomena in S.I. engines; Ignition limits, stages of combustion in S.I. Engines, Ignition lag, velocity of flame	3

	propagation, auto ignition, detonation; effects of engine variables on detonation; theories of detonation,	
4.3	Octane rating of fuels; pre-ignition; S.I. engine combustion chambers. Combustion in C.I. Engines; delay period; variables affecting delay period;	3
4.4	knock in C.I. engines, Cetane rating; C.I. engine combustion chambers.	2
5		
5.1	Refrigeration– Reversed Carnot cycle, Air refrigeration system-Reversed Joule cycle.	2
5.2	Vapour compression systems-simple cycle - representation on T- s and P- h Diagrams.	2
5.3	Psychometric properties – specific humidity, relative humidity and degree of saturation-	1
5.4	Thermodynamic equations- enthalpy of moisture- DBT, WBT and DPT–psychrometers, psychometric chart.	2
5.5	Comfort and industrial air conditioning, Comfort air conditioning-factors affecting human comfort, Effective temperature, comfort chart, Summer air conditioning,	2

CODE	MACHINE TOOLS ENGINEERING	CATEGORY	L	T	P	Credits
MET385		**VAC**	**3**	**1**	**0**	**4**

Preamble:

This course facilitate students to learn about various machine tools and operations performed on them. Theoretical foundation offered by this course must help the learners to make appropriate decisions vis-a-vis preliminary planning and selection of machine tools, acquiring adequate supervisory skills and to help the learners to efficiently interact with their peers to arrive at solutions for day-to-day shop floor problems.

Prerequisite:
MET285 Material Science and Technology (Minor), MET286 Manufacturing Technology (Minor)

Course Outcomes: After the completion of the course the student will be able to:

CO 1	Describe basic concepts involved in metal cutting.
CO 2	Differentiate between machine tools, their components, operations carried out and their unique metal removing mechanisms.
CO 3	Describe how to specify machine tools and cutting tools.
CO 4	Calculate the time required for machining.
CO 5	Clarify advantages of CNC over manual machine tools.
CO 6	Clarify how non-conventional machining techniques are advantageous to finish jobs with intricate profiles and closer tolerances.

Mapping of course outcomes with program outcomes:

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	-	-	-	-	-	-	-	2	-	-	-
CO 2	1	-	1	-	3	-	-	-	2	1	-	-
CO 3	-	-	-	2	-	-	-	-	2	-	1	-
CO 4	3	2	-	-	-	-	-	-	2	-	-	-
CO 5	-	-	-	-	2	-	-	-	2	-	-	2
CO 6	-	-	-	-	-	-	1	-	2	-	-	1

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination (marks)
	1 (marks)	2 (marks)	
Remember	15	15	35
Understand	15	15	35
Apply	10	10	15
Analyse	10	10	15
Evaluate	-	-	-
Create	-	-	-

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Describe the geometry of a single point cutting tool with a neat diagram.
2. Define machinability.
3. List various cutting tool materials and their applications.

Course Outcome 2 (CO2):

1. Examine two reasons for centre drilling on lathe.
2. Differentiate between up milling and down milling.
3. Differentiate a wire-cut EDM from a general purpose EDM.

Course Outcome 3 (CO3):

1. List all specification parameters of a lathe.
2. Specify a plain milling cutter.
3. Specify a twist drill.

Course Outcome 4 (CO4):

1. Calculate the time required for drilling a 20 mm hole in metal blank having thickness of 36 mm. The cutting speed is 15 metres/minute and feed is 0.2 mm/revolution.
2. Calculate the r.p.m. of lathe to obtain a cutting speed of 25 metres/minute, when turning a rod of diameter 32 mm diameter.
3. Calculate machining time for cylindrical grinding, if length of longitudinal travel =500 mm, feed =1.0 mm/revolution and work piece r.p.m = 500 in a single pass.

Course Outcome 5 (CO5):

1. Clarify whether a conventional machine tool can be retrofitted with a CNC system.
2. Describe advantages of CNC system in manufacturing.
3. Distinguish between open loop system and closed loop system by giving an example for each.

Course Outcome 6 (CO6):

1. Describe advantages of WJM over traditional punching/manual cutting
2. Compare process capabilities of conventional drilling and laser beam drilling.
3. Clarify why an EDM is not used as a replacement to CNC milling machine.

MODEL QUESTION PAPER

FIFTH SEMESTER MECHANICAL ENGINEERING

MET385 MACHINE TOOLS ENGINEERING

Max. Marks: 100 Duration: 3 hours

Part−A

Answer all questions. Each question carries 3 marks.

1. State the effect of cutting speed, feed and depth of cut on surface finish obtainable.
2. Explain why built up edge on a tool is undesirable.
3. A brass pin of 500 mm length and 40 mm diameter is turned on a lathe to 38.8 mm diameter in one pass. The cutting speed is 60 metres/minute and feed is 0.8 mm/min. Calculate the machining time.
4. How do you specify (a) portable drilling machine (b) radial drilling machine (c) multiple spindle drilling machine.
5. List various operations that can be performed on a milling machine.
6. Differentiate between grain and grade in a grinding wheel.
7. Bring out the differences between continuous path control and point-to-point positioning.
8. List the generic advantages of CNC system over their manual counterparts.
9. Discuss the characteristics of dielectric fluids used in EDM.
10. List the advantage of WJM over traditional cutting.

Part−B

Answer one full question from each module.

Module I

11. (a) Sketch the three views of a 25 mm single point square tool bit having tool signature as indicated below: 15,15,10,10,15,10 (3 mm) (7 marks)

(b) Define machinability. Discuss all variables affecting machinability.

(7 marks)

12. (a) Discuss various cutting tool materials and their applications.

(b) Define tool failure. List and explain 2 reasons for normal tool wear. (7 marks)

(7 marks)

Module II

13. Describe construction details of an engine lathe with a neat illustration. (14 marks)

14. Draw and explain any four operations carried out in a lathe. (14 marks)

Module III

15. Draw and explain up milling and down milling. Decide which type is suitable to prevent backlash. (14 marks)

16. List all factors to be considered for selection of grinding wheels. Discuss each in detail. (14 marks)

Module IV

17. Discuss all elements of a CNC system with a suitable block diagram. (14 marks)

18. Discuss construction details of a CNC lathe and compare process capability of CNC lathe with that of a manual lathe. (14 marks)

Module V

19. Describe ultrasonic drilling process giving areas of application. (14 marks)

20. Discuss construction and operation of a wire-cut EDM system with the help of a suitable diagram. (14 marks)

Syllabus

Module 1

Definition of machining–brief history of machining–role of machining in society. Introduction to metal cutting: Elements of cutting process– orthogonal cutting– mechanism of chip formation–machining variables -types of chips–chip breaker– geometry of single point cutting tool– tool nomenclature- speed, feed, depth of cut – cutting fluids- effect of machining variables on surface roughness- Cutting tool materials–types–application. Machinability–tool life and wear.

Module 2

General purpose machine tools – Lathe: principle of operation of lathe–construction details of lathe–work holding and tool holding parts of lathe– types of lathe and specification–machining time calculation on lathe–main operations. Drilling Machines: principle of operation-construction details- work holding and tool holding devices– types of drilling machine and specification. Twist drill geometry–specification–calculation of machining time in drilling.

Module 3

Milling machines: Principle of operation of milling machine-types and specifications–principal parts-work holding devices–types of milling cutters-elemental milling motions-up milling, down milling calculation of machining time. Grinding machines: classification –operations– surface, cylindrical and centerless grinding–grinding wheels–specification–types of abrasives, grain size. Dressing and truing of grinding wheels–selection of grinding wheels.

Module 4

Machine tools with Computer Numeric Control: Principle of operation of CNC system–basic components of CNC system– classification of CNC systems– open loop control and closed loop control– point to point and continuous path control– absolute positioning and incremental positioning–CNC lathe–construction and operation – CNC milling machine–construction and operation (elementary treatment only)

Module 5

Non-conventional techniques in machining: Electric Discharge Machining (EDM): mechanisms of metal removal- elements of an EDM– spark generation– application of EDM – Wire-cut EDM-features. UltraSonic Machining (USM): mechanism of metal removal- elements of USM-applications. Water Jet Machining (WJM): mechanism of metal removal-elements of WJM-applications.

Text Books

1. R.K.Jain, Production Technology, Khanna publishers, 17th ed., 2013.
2. Hajra Choudhary, Elements of Workshop Technology Vol. II, Media Promoters & Publishers Pvt. Ltd., 2010.

Reference Books

1. Serope Kalpakjian, Steven R. Schmid – Manufacturing Engineering and Technology, 8th ed. Pearson.
2. Chapman W.A.J., Workshop Technology, Viva books (P) Ltd, 1998.
3. Peter J. Hoffman, Eric S. Hopewell et al., Precision Machining Technology, Cengage Learning, 2014.
4. Malkin Stephen, Grinding Technology: Theory and application of Machining with Abrasives, Industrial press, 2008.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures	COs
1.1	Definition of Machining–brief history of machining–role of machining in society – automotive- aerospace– medical–consumable goods.	1	CO1
1.2	Introduction to metal cutting–elements of cutting process–work piece-tool interaction in orthogonal cutting- rake angle, shear angle, cutting angle, clearance angle–mechanism of chip formation–chip breaker.	1	CO1
1.3	Machining variables- geometry of chips (types of chips)- cutting speed, feed, depth of cut- tool geometry (single point)-nomenclature-cutting fluids.	3	CO1
1.4	Effect of machining variables on surface roughness.	2	CO1
1.5	Cutting tool materials and application.	1	CO1
1.6	Machinability-factors affecting it –machinability index.	1	CO1
1.7	Tool life and tool wear.	1	CO1
2.1	General purpose machine tools– lathe- principle and operation of lathe-how to specify a lathe-types of lathe.	1	CO2 CO3
2.2	Construction details of engine lathe-work holding and tool holding parts of lathe.	2	CO2
2.3	Main operations in lathe- machining time calculation of plain turning.	2	CO4

2.4	Drilling machines – principle of operation-construction details.	1	CO2
2.5	Work holding and tool holding devices.	2	CO2
2.6	Types of drilling machine- specification of radial drilling machine.	1	CO3
2.7	Twist drill geometry and specification- calculation of drilling time.	1	CO4
3.1	Milling machine- purpose and principle of operation-types an specification.	1	CO2
3.2	Differentiate Horizontal milling machine and vertical milling machine – principal parts and work holding devices of vertical milling machine.	1	CO2
3.3	Types of milling cutters- elemental milling movements- up milling, down milling – calculation of plain milling time.	2	CO4
3.4	Grinding machines- classification- surface, cylindrical and centre less grinding.	1	CO2
3.5	Grinding wheels‒specification‒types of abrasives, grain size‒dressing and truing of grinding wheels‒selection of grinding wheels.	3	CO3
4.1	Machine tools with CNC- principle of operation of CNC – basic components (block diagrams)	2	CO2
4.2	Classification of CNC systems‒ open loop control and closed loop control‒ point-to-point and continuous path control‒ absolute positioning and incremental positioning.	2	CO5
4.3	CNC lathe- construction and operation (elementary treatment)	2	CO5
4.4	CNC milling machine- construction and operation (elementary treatment)	2	CO5
5.1	Non-conventional techniques in machining: Electric Discharge machining (EDM): mechanism of metal removal- elements of an EDM‒ physics of spark generation.	2	CO6
5.2	Applications of EDM process.	1	CO6
5.3	Wire-cut EDM-features and applications.	1	CO6
5.4	Ultrasonic Machining (USM): mechanism of metal removal- elements of USM-applications.	2	CO6
5.5	Water Jet Machining (WJM): mechanism of metal removal-elements of WJM- applications.	2	CO6

SEMESTER V

HONOURS

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
MET 393	EXPERIMENTAL STRESS ANALYSIS	VAC	3	1	0	4

Preamble:

The course imparts to the students, the basic aspects of theory of elasticity and stress-strain relationship as well as experimental stress analysis that includes the most versatile techniques like photo elasticity, strain gauges and non-destructive test (NDT) methods.

Course Outcomes:

After the completion of the course the student will be able to

CO 1 Analyse the stresses, strains and deformations of structures under 2- and 3-dimensional loading by tensorial and graphical (Mohr's circle) approaches

CO 2 Describe the different instrument used for strain measurement materials using stress-strain relationships.

CO 3 Explain the concept behind the measurement and instrumentation.

CO 4 Describe the concept behind Photo elasticity and brittle coating.

CO 5 Describe the different NDT methods to evaluate the strength.

Mapping of course outcomes with program outcomes assessment Pattern

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3	2	1								1
CO 2	3	3	1	1								1
CO 3	3	2	1	1								1
CO 4	3	2	1	1								1
CO 5	3	1	1	1								1

Assessment Pattern

Blooms Category	Continuous Assessment Tests		ESE
	1	2	
Remember			
Understand	40	40	80
Apply		10	10
Analyse	10		10
Evaluate			
Create			

Mark Distribution

Total Marks	CIE	ESE	ESE Duration	
150	**50**	**100**	**3 Hrs**	

Continuous Internal Evaluation Pattern

Attendance	10
Continuous Assessment Tests (2 nos)	25
Assignments/ Quiz/ Course Project	15

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

COURSE LEVEL ASSESSMENT QUESTIONS

Course Outcome 1 (CO1): Analyse the stresses, strains and deformations of structures under 2- and 3-dimensional loading by tensorial and graphical (Mohr's circle) approaches.

1. Determine the resultant traction at a point in a plane using the stress tensor.
2. Evaluate the principal stresses, principal strains and their directions from a given state of stress or strain.
3. Write the stress tensor and strain tensor.

Course Outcome 2 (CO2): Describe the different instrument used for strain measurement materials using stress-strain relationships.

1. With help of fig, explain the construction and working of any one type of strain gauge.
2. Explain how strain can be measured over a long time at high and low temperature.
3. Explain how the delta rosette can be used for analysing the strain.

Course Outcome 3 (CO3): Describe the concept behind the measurement and instrumentation.

1. Describe Range and Sensitivity of a circuit
2. Define error, accuracy and precision with respect to measuring instrument.
3. With help of fig, Describe any one type of displacement measuring transducer.

Course Outcome 4 (CO4): Describe the concept behind Photo elasticity and brittle Coating.

1. Enumerate different steps involved in brittle coating.
2. Describe the effect of stressed model in plane polariscope.
3. Describe compensation techniques in photo elasticity.

Course Outcome 5 (CO5): Describe the different NDT methods to evaluate the strength.

1. Describe dye penetrant test with help of figure.
2. Explain penetrameter with help of figure.
3. With help of figure, explain Magnetic particle test.

MODEL QUESTION PAPER

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIFTH SEMESTER B.TECH DEGREE EXAMINATION

MET 393 EXPERIMENTAL STRESS ANALYSIS

Max. Marks:100 Duration: 3Hours

PART – A
(*ANSWER ALL QUESTIONS, EACH QUESTION CARRIES 3 MARKS*)

1. Define stress at a point.
2. Explain principal stresses and strain.
3. How static and dynamic strain can be measured over a strain circuits.
4. What are residual stresses? What are its beneficial and harmful effects?
5. What are transducers? What are its properties?
6. Explain the different principles of measurements
7. Define stress optic law
8. What are the main uses of photo elastic coatings?
9. Distinguish between Destructive testing and Non-destructive testing.
10. What are the properties of X rays and Gamma rays.

PART – B
(*ANSWER ONE FULL QUESTION FROM EACH MODULE*)

MODULE – 1

11. The state of stress at a point is given by the Cartesian stress tensor $\begin{matrix} 3 & -1 & 1 \\ -1 & 5 & -1 \\ 1 & -1 & 3 \end{matrix}$ Kpa. Find (a) the stress invariant (b) characteristic equation (c) Principal stresses (d) Unit normal of the principal planes. (14marks)

12. a) Derive the expression for Cauchy's equation for stress on a given plane, normal stress & shear stress. (7marks)

b) Derive stress compatibility equation of plane strain problems. (7marks)

MODULE – 2

13. a) With help of neat sketch, explain a mechanical strain gauge (7 marks)

b) Explain how rectangular rosette can be analyzed for strain measurement. (7 marks)

14. a) With help of fig, explain a optical strain gauge. (7 Marks)

b) Describe how strain can be measured over a long period at low and high temperature. (7 marks)

MODULE – 3

15. a) with help of figure, explain the working of cathode ray oscilloscope. (7 marks)

b) With help of fig, explain the working of displacement transducer. (7 marks)

16. a) Prove that constant current potentiometer circuit has more sensitivity than that of a constant voltage circuit (7 marks)

b) With help of fig, explain the working of force transducer. (7 marks)

MODULE – 4

17 a) Describe the different types of available brittle coatings. (7marks)

b) Obtain the expression for intensity of light emerging from a plane polariscope with dark field set up. (7marks)

18 a) With help of fig, explain Tardy's method of compensation. (10 marks)

b) Explain isochromatic and isoclinics fringe pattern (4 marks)

MODULE – 5

19. a) Explain laser testing methods in NDT. (7 marks)

b) With help of fig, explain the steps involved in LPI. (7 marks)

20. a) With help of fig, explain Radiography test. (7 marks)

b) Explain the working of X – ray fluoroscopy (7 marks)

SYLLABUS

Module 1: Analysis of deformable bodies: stress, stress at a point using Cartesian stress tensor, Cauchy's equation for stress on a given plane, normal stress & shear stress; Strain, deformation and displacement (in Cartesian coordinates), strain components, 2D plane stress and plane strain problems, principal stresses (2D & 3D), stress invariants, Mohr's circle representation for stress in 2D and problems, representation 3D stress in Mohr's circle using principal stresses as input.

Module 2: Strain measurements: strain gauges and stress gauges. Mechanical, optical and electrical gauges – Construction and applications. Variable resistance strain gauges, gauge characteristics, gauge sensitivity, static and dynamic strain – strain measurement over a long period at low and high temperature. Strain rosettes – Rectangular rosettes, Delta rosettes. Residual stresses : Beneficial and harmful effects.

Module 3: Instrumentation: Strain circuits, potentiometer circuits, Range and sensitivity, The wheatstones bridge, sensitivity, Galvanometer, Transient response, Principles of measurements: Error, Accuracy and precision , Uncertainty analysis, Curve fitting. Oscillograph, cathode ray oscilloscope, Transducers – Displacement, Force, Pressure, velocity and acceleration.

Module 4: Photo elasticity: The polariscope, Stress optic law, Polariscope arrangements – Plane polariscope and Circular Polariscope. Dark field and light field, isochromatic and isoclinics, Use of photo elastic coatings, compensation techniques.
Brittle coatings: Coating stresses, Failure theories, steps in brittle coating tests.

Module 5: Non Destructive testing Methods – Types – dye penetrant methods, Radiography – X – ray and Gamma ray – X – ray fluoroscopy. Penetrameter – Magnetic particle methods. Introduction to lasers in NDT – Ultrasonic flaw detection.

Text Books

1. J. W. Dally and W. F. Riley, Experimental Stress Analysis - McGraw Hill, 1991
2. L.S.Srinath, M R Raghavan, K Lingaiah, G Gargesa, B Pant, and K . Ramachandra, Experimental Stress Analysis, Tata Mc Graw Hill, 1984.
3. A. Mubin, Experimental Stress Analysis, Khanna Publishers, 2003.
4. Sadhu Singh, Experimental Stress Analysis, Khanna Publishers, 1996.

Reference Books

1. M.Hetenyi, Handbook of Experimental Stress Analysis, John Wiley & Sons Inc, New York, 1950
2. C.C. Perry and H.R.Lissener, Strain Gauge Primer, McGraw Hill, 2nd Ed , 1962 .

3. W.J.McGonnagle Non destructive Testing Mc Graw Hill, 1961 .

COURSE PLAN

No	Topic	No. of Lectures
1	**Module 1: Stress and Strain Analysis**	**9 hrs**
1.1	Describe the deformation behaviour of elastic solids in equilibrium under the action of a system of forces. Describe method of sections to illustrate stress as resisting force per unit area. Stress vectors on Cartesian coordinate planes passing through a point .	1 hr
1.2	Direction cosines of a plane. Equality of cross shear (Derivation not required). Write Cauchy's equation (Derivation not required) for stress on a plane as the product of stress tensor and direction cosine vector. Normal and tangential (shear) components of stress on a plane.	1 hr
1.3	Deformation, displacement, gradient of deformation and strains in elastic solids. Cartesian components of strain and Cauchy's strain-displacement relationships (small-strain only). Strain tensor in 2D and 3D. Write the stress tensor and strain tensor for Plane stress and Plane Strain analysis.	1 hr
1.4	Stress on an oblique plane under axial loading, Discuss principal planes, characteristic equation to find principal stresses for 2D and 3D state of stress, stress invariants. Evaluate principal stresses in 2D and 3D using characteristic equations.	2 hrs
1.5	Discuss the order of principal stress and maximum shear stress. Compare the principal stresses in 2D and 3D state of stress. Represent the state of stress using principal stress tensor. Determine the direction of principal stresses as eigenvectors of the principal stress tensor.	2 hrs
1.6	Represent the 2D and 3D state of stress using principal stress graphically (Mohr's circle). Determine the maximum shear stress by Mohr's circle method and compare with the theoretical relations.	2 hrs
2	**Module 2: Strain measurements**	**8 hrs**
2.1	Strain gauges and stress gauges, Different types of strain gauges – construction and working, Different application of strain gauges. Variable resistance strain gauge	2 hr
2.2	Gauge characteristics, gauge sensitivity, measurement of static and dynamic strain, and measurement of strain over a long period at high and low temperature.	2 hrs
2.3	Strain rosette - Rectangular rosettes and Delta rosettes (simple problems).	2 hrs
2.4	Residual stresses, harmful effects of residual stresses, beneficial effects of residual stresses.	2 hrs
3	**Module 3 :Instrumentation**	**9 hrs**
3.1	Strain circuits, potentiometer circuits, Range and sensitivity, The wheatstones bridge.	2 hrs
3.2	Principles of measurements: Error, Accuracy and precision,	1 hr

	Uncertainty analysis, Curve fitting.	
3.3	Oscillograph ,cathode ray oscilloscope,	1 hr
3.4	Transducer – Characteristics and properties.	1 hr
3.5	Displacement transducer – Construction and working, Pressure transducer - Construction and working.	2 hrs
3.6	Velocity transducer - Construction and working	1 hr
3.7	Acceleration transducer - Construction and working.	1 hr
4	**Module 4 : Photoelasticity.**	**8 hrs**
4.1	The polariscope, Stress optic law, Polariscope arrangements – Plane polariscope and Circular Polariscope.	2 hrs
4.2	Dark field and light field , isochromatics and isoclinics , Use of photoelastic coatings.	2 hrs
4.3	Different types of compensation techniques.	2 hrs
4.4	Coating stresses, Failure theories, steps in brittle coating tests.	2 hr
5	**Module 5 :Non Destructive Methods.**	**8 hrs**
5.1	Non Destructive testing Methods – Types – dye penetrant methods, Radiography – X – ray and Gamma ray.	2 hrs
5.2	X – ray fluoroscopy , Penetrameter (Detailed description)	2 hr
5.3	Magnetic particle methods, advantages and disadvantages, applications.	2 hrs
5.4	Introduction to lasers in NDT – Ultrasonic flaw detection.	2 hrs

CODE MET395	COURSE NAME ADVANCED THERMODYNAMICS	CATEGORY	L	T	P	CREDIT
		VAC	3	1	0	4

Preamble: This course involves the application of principles studied in thermodynamics for analysis of thermal energy systems. This course also covers the properties of pure substances, Energy balance of reacting systems and advances in chemical thermodynamics.

Course Outcomes: After the completion of the course the student will be able to

CO 1	Apply the concepts of basic thermodynamics, entropy and energy for analyses of thermal energy systems.
CO 2	Understand properties of pure substance and thermodynamic properties of real gases
CO 3	Apply energy balances to reacting systems for both closed and open system.
CO 4	Define the chemical equilibrium constant and apply the general criteria for chemical equilibrium analysis to reacting ideal-gas mixtures.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	**3**	3	2									
CO 2	**3**	3	2									
CO 3	**3**	3	2									
CO 4	**3**	3	2									

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	10
Understand	10	10	20
Apply	20	20	50
Analyse	10	10	20
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. One kg of water at 273 K is brought into contact with a heat reservoir at 373 K. When the water has reached 373 K , find the entropy change of water, of the heat reservoir and of the universe.

2. State and prove Clausius Theorem

3. Water at 363 K flowing at the rate of 2 kg/s mixes adiabatically with another stream of water at 303 K flowing at the rate of 1 kg/s. Estimate the entropy generation rate and rate of exergy loss due to mixing. Take T_0 = 300 K

Course Outcome 2 (CO2)

1. A large insulated vessel is divided into two chambers one containing 5 kg of dry saturated steam at 0.2 MPa and the other 10 Kg of steam 0.8 quality at 0.5 MPa. If the partition between the chambers is removed and the steam is mixed thoroughly and allowed to settle, find the final pressure , steam quality and entropy change in the process

2. Draw the phase equilibrium diagram for a pure substance on h-s plot with relevant constant property lines.

3. Show that for an ideal gas the slope of the constant volume line on the T-S diagram is more than that of the constant pressure line.

Course Outcome 3(CO3):

1. Determine the adiabatic flame temperature when liquid octane at 298 K is burned with 300% theoretical air at 298 K in a steady flow process

2. What is heat of reaction? When is it positive and when negative?

3. Calculate the degree of ionization of cesium vapour at 10^{-6} atm at the two temperatures of 2260 and 2520 K

Course Outcome 4 (CO4):

1. Explain law of mass action
2. Explain reaction equilibrium constant.
3. Discuss second law analysis of reactive systems

MODEL QUESTION PAPER

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

V SEMESTER BTECH DEGREE EXAMINATION

MET395: ADVANCED THERMODYNAMICS

Maximum: 100Marks Duration:3 hours

PART A

Answer all questions, each question carries 3 marks

1. Show that entropy is a property of the system
2. What is the meaning of quality of energy
3. Draw the phase equilibrium diagram for a pure substance on T-s plot with relevant constant property lines.
4. Write Clausius – Clapeyron equations
5. Explain law of corresponding states
6. Explain Wander-Walls equation of state
7. Explain Second-Law Analysis of Reacting systems
8. What do you meant by adiabatic flame temperature?
9. Explain law of mass action
10. What is van’t Hoff equation

(10×3=30Marks)

PART B

Answer one full question from each module

MODULE 1

11. Three identical finite bodies of constant heat capacity are at temperatures 300, 300 and 100 K. If no work or heat is supplied from outside, what is the highest temperature to which any one of the bodies can be raised by the operation of heat engines or refrigerators (14 marks)

12. A pressure vessel has a volume of 1m3 and contains air at 1.4 MPa, 448K. The air is cooled to 298K by heat transfer to surroundings at 298 K. Calculate the availability in the initial and final states and irreversibility of the process. Take P0 = 100kPa (14 marks)

MODULE 2

13. Steam initially at 0.3 MPa, 523K is cooled at constant volume. Find

a) Temperature at which steam become saturated vapour,

b) What is the quality at 353 K,

c) What is the heat transferred per kg of steam in cooling from 523 K to 353 K

(14 marks)

14. Derive Maxwell relations and TdS equations (14 marks)

MODULE 3

15. a) What are virial coefficients ? When do they become zero? (7 Marks)

b) Express Wander – Walls constants in terms of critical properties (7 marks)

16. Calculate the volume of 2.5 Kg moles of steam at 236.4 atm. And 776.76 K with the help of compressibility factor vs reduced pressure graph. At this given volume and pressure what would be the temperature in K, if steam behaves like a Vander-Walls gas. The critical pressure, volume and temperature of steam are 218.2 atm, 57 cm3/g mole and 647.3 K respectively.

(14 marks)

MODULE 4

17. a) Explain second law efficiency of a reactive system ? (4 marks)

b) Explain first law analysis of reactive systems. (10 Marks)

18. The products of combustion of an unknown hydrocarbon CxHy have the following composition a measured by an Orsat apparatus

CO_2 8%, CO 0.9%, O_2 8.8% and N_2 82.3 % Find a) Composition fuel b) air-fuel ratio and c) percentage of excess air used. (14 marks)

MODULE 5

19. a) What is Gibbs function of formation (5 marks)

b) Explain the phase equilibrium for a single component system

(9 marks)

20. a) What is degree of reaction (5 marks)

b) Explain the phase equilibrium for a multi component system (9 marks)

Syllabus

Module 1

RECAPITULATION OF FUNDAMENTALS. Basic definition and concepts; The basic laws of Thermodynamics, Entropy flow and entropy production, 3rd law of Thermodynamics, Availability in steady flow open system and in a closed system, Irreversibility and effectiveness.

Module 2

PROPERTIES OF PURE SUBSTANCES. P-V-T surfaces, phase diagram, phase changes, various properties diagram, 1st order phase transition and 2nd order phase transition, Clapeyron's equation, Ehrenfest's equations, Maxwell's equations, equation for internal energy, enthalpy, entropy, specific heat and joule Thompson coefficient.

Module 3

EQUATION OF STATE FOR REAL GASES. Compressibility factor and generalised compressibility chart, Law of corresponding state, law of pseudo critical pressure and temperature, reduced coordinate, Wander-Walls equation of state and other equation of state.

Module 4

CHEMICAL REACTION. Fuels and Combustion, First-Law Analysis of Reacting Systems: Steady-Flow Systems and Closed Systems, Entropy Change of Reacting Systems, Second-Law Analysis of Reacting systems.

Module 5

CHEMICAL THERMODYNAMICS. Gibb's theorem, Gibbs function of mixture of inert ideal gases, Chemical equilibrium, Thermodynamic equation for phase, Degree of reaction, equation of reaction, law of mass action, heat of reaction and Vant Hoff Isober, Phase Equilibrium for a Single-Component System and Multi-Component System

Text books:

1. Richard Edwin Sonntag , G.J. Van Wylen, Introduction to Thermodynamics- Classical and Statistical Wiley , 1991

2. Cengel and Boles.,Thermodynamics : An engineering Approach McGraw-Hill, 2007 Sixth Edition

3. P.K. Nag. Engineering Thermodynamics Tata McGraw -Hill , 2013

Reference books:

1. M. Zemansky, R H Dittman. Heat and Thermodymics –7th Edition 1998

2. E. F . Obert, Concepts of thermodynamics – McGraw-Hill, 1963

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1		
1.1	Basic definition and concepts; The basic laws of Thermodynamics,	3
1.2	Entropy flow and entropy production, 3rd law of Thermodynamics,	2
1.3	Availability in steady flow open system and in a closed system	2
1.4	Irreversibility and effectiveness.	2
2		
2.1	PROPERTIES OF PURE SUBSTANCES. P-V-T surfaces, phase diagram, phase changes, various properties diagram,	3
2.2	1st order phase transition and 2nd order phase transition, Clapeyron's equation, Ehrenfest's equations,	3
2.3	Maxwell's equations, equation for internal energy, enthalpy, entropy, specific heat and joule Thompson coefficient.	3
3		
3.1	EQUATION OF STATE FOR REAL GASES. Compressibility factor and generalised compressibility chart,	2
3.2	Law of corresponding state	2
3.3	law of pseudo critical pressure and temperature	3
3.4	Reduced coordinate, Wander-Walls equation of state and other equation of state.	2
4		
4.1	CHEMICAL REACTION. Fuels and Combustion,	1
4.2	First-Law Analysis of Reacting Systems: Steady-Flow Systems and Closed Systems	3
4.3	Entropy Change of Reacting Systems	2
4.4	Second-Law Analysis of Reacting systems	3
5		
5.1	CHEMICAL THERMODYNAMICS. Gibb's theorem, Gibbs function of mixture of inert ideal gases,	2
5.2	Chemical equilibrium, Thermodynamic equation for phase,	2
5.3	Degree of reaction, equation of reaction, law of mass action,	2
5.4	Heat of reaction and Vant Hoff Isober, Phase Equilibrium for a Single-Component System and Multi-Component System	3

CODE	COURSENAME	CATEGORY	L-T-P	CREDITS
MET 397	FLUID POWER AUTOMATION	VAC	3-1-0	4

Preamble :

This course provides basic ideas of fluid power automation. It enables the students to design and optimize pneumatic and hydraulic automation systems.

Prerequisite : Nil

Course Outcomes :

After completion of the course the student will be able to

CO1	Explain the concept of power generating elements
CO2	Describe fundamentals of actuator and accumulator
CO3	Explain in detail control and regulation elements
CO4	Illustrate different circuit design methods
CO5	Illustrate electrical control of pneumatic and hydraulics circuits

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1									
CO2	3	2										
CO3	3	2	1									
CO4	3	1										
CO5	3	1										

Assessment Pattern

Bloom Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	10
Understand	20	20	20
Apply	20	20	70
Analyse			
Evaluate			
Create			

Mark Distribution and duration of ESE

Total Marks	CA	ESE	ESE Duration
150	50	100	3 Hours

Continuous Internal Evaluation Pattern

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End semester pattern:

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions:

Course Outcome 1 (CO1):

1. Explain the need and benefits of automation.
2. Discuss the various components of a fluid power system.
3. Discuss about the hydraulic and pneumatic element selection criteria based with respect to a typical example.

Course Outcome 2 (CO2):

1. Write a detailed note on Linear Actuators.
2. Give a short notes on (a) Spring Return Single acting Cylinder and (b) Double acting cylinder with a piston rod on both sides
3. Make a circuit sketch showing the use of accumulators as a shock absorber.

Course Outcome 3 (CO3):

1. Explain different types of direction and flow control valves.
2. Explain the components of closed loop hydraulic systems with a block diagram.
3. With a neat sketch, describe the construction and working of pressure compensated flow control valve.

Course Outcome 4 (CO4):

1. Construct a ladder diagram for a hydraulic circuit with six cylinders used to control industrial robot.
2. Describe combinational and sequential logical circuits.
3. Design and develop a hydraulic circuit for the following sequence using cascade method. A+ B+ C+

Course Outcome 5 (CO5):

1. Explain basic electrical devices used in electro pneumatic circuits.
2. Explain the functions of relays, timers andcounters in hydraulic and pneumatic circuits.
3. Explain the basic structure of a PLC.

MODEL QUESTION PAPER
APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
V SEMESTER B.TECH DEGREE EXAMINATION
MET397: FLUID POWER AUTOMATION

Maximum: 100 Marks **Duration: 3 hours**

PART A

Answer all questions, each question carries 3 marks

1. What are the limitations of fluid power automation?
2. What are the factors to be considered in the selection of pump?
3. Define spool valve?
4. How is counter represented in ladder diagram?
5. What is a linear actuator?
6. What is the function Karnaugh map?
7. Define underlap and overlap in the context of servo valve spools?
8. What are the uses of relays in hydraulic and pneumatic circuits?
9. What is the function of intensifier?
10. List the components of PLC. (10 X 3 = 30 marks)

PART B

Answer one full question from each module

Module 1

11. Describe in brief with neat sketches any 16 ISO symbols used for fluid power elements. (14 marks)
12. Briefly explain the working and construction details of Vane pump with a diagram (14 marks)

Module 2

13. Describe the working principle of hydraulic accumulators (14 marks)
14. With a neat sketch, explain the end cushion provided in hydraulic cylinder (14 marks)

Module 3

15. Draw a neat sketch and explain the working of pressure and temperature compensated flow control valve (14 marks)
16. Write short notes on direction control valves and its types with neat sketches (14 marks)

Module 4

17. Draw and explain the working principle of fail-safe circuit with overload protection (14 marks)
18. Design and draw a hydraulic circuit for A+B+B+A+ sequencing operation and explain. (14marks)

Module 5

19. Design and draw electro hydraulic circuit for hydraulic motor braking system

(14 marks)

20. a) Draw the fluid power symbols of any 4 accessories (4 marks)
    b) Describe the advantages and disadvantages of fluid power systems

(10 marks)

Syllabus

Module 1

Need for automation, classification of drives- hydraulic and pneumatic –comparison ISO symbols for fluid power elements, selection criteria Fluid power generating elements-hydraulic pumps and motorgears, vane, piston pumps-motors-selection and specification

Module 2

Drive characteristics- linear actuator–types, mounting details, cushioning–power packs–accumulators

Module 3

Control and regulation elements—direction, flow and pressure control valves-methods of actuation, types, sizing of ports. Spool valves- operating characteristics, electro hydraulic servo valves-different types-characteristics and performance

Module 4

Typical design methods –ladder diagram- sequencing circuits design - combinational logic circuit design-cascade method - Karnaugh map method.

Module 5

Electrical control of pneumatic and hydraulic circuits- use of relays, timers, counters, interfacing with PLCs, proportional control of hydraulic systems

Text Books:

1. Alavudeen A, Fluid Power Transmission and Control, Charotar Publishing House, 2007
2. Jagadeesha T, Hydraulics and Pneumatics, I K International Publishing House, 2015
3. AntonyEsposito,FluidPowerSystemsandcontrol,Prentice-Hall,1988

Reference Books:

1. PeterRohner,FluidPowerlogiccircuitdesign, MacmillanPress, 1994.
2. E.C.FitchandJ.B.Surjaatmadja.Introductiontofluidlogic,McGrawHill, 1978
3. HerbertE.Merritt,Hydrauliccontrolsystems,JohnWiley&Sons,1967
4. Dudley.A.Pease,BasicFluidPower,PrenticeHall,1967

Course Contents and Lecture Schedule

No.	Topic	No. of Lectures
I	Need for automation, classification of drives- hydraulic and pneumatic – comparison, ISO symbols for fluid power elements, selection criteria	**4**
	Fluid power generating elements **– h**ydraulic pumps and motorgears, vane, piston pumps-motors- selection and specification	**5**
II	Drive characteristics- linear actuator–types, mounting details, cushioning–power packs–accumulators	**9**
III	Control and regulation elements—direction, flow and pressure control valves- methods of actuation, types, sizing of ports, spool valves-operating characteristics, Electro hydraulic servo valves-different types-characteristics and performance	**10**
IV	Typical design methods –Ladder diagram- sequencing circuits design - combinational logic circuit design-cascade method – Karnaugh map method.	**9**
V	Electrical control of pneumatic and hydraulic circuits- use of relays, timers, counters ,interfacing with PLCs, proportional control of hydraulic systems	**8**

SEMESTER VI

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
MET302	HEAT &MASS TRANSFER	PCC	3	1	0	4

Preamble:

The objectives of the course are:

- To introduce the various modes of heat transfer and to develop methodologies for solving a wide variety of practical heat transfer problems
- To provide useful information concerning the performance and design of simple heat transfer systems
- Conceive the energy balance in any thermal practical situation involving heat transfer mechanisms.
- To introduce mass transfer.

Prerequisite: MET203 Mechanics of Fluids, MET202 Engineering Thermodynamics

Course Outcomes: After the completion of the course the student will be able to

CO 1	Apply principles of heat and mass transfer to engineering problems
CO 2	Analyse and obtain solutions to problems involving various modes of heat transfer
CO 3	Design heat transfer systems such as heat exchangers, fins, radiation shields etc.
CO 4	Define laminar and turbulent boundary layers and ability to formulate energy equation in flow systems.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3	2									1
CO 2	3	3	3									2
CO 3	3	3	3									2
CO 4	3	3	3									2

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	10
Understand	20	10	20
Apply	10	20	50
Analyse	10	10	20
Evaluate			
Create			

Mark distribution

Total Marks	**CIE**	**ESE**	**ESE Duration**
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10marks
Continuous Assessment Test(2numbers) : 25 marks
Assignment/Quiz/Course project : 15marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. A furnace wall is made up of three layers of thicknesses 250 mm, 100 mm and 150 mm with thermal conductivities of 1.65 W/m.K and 9.2 W/m.K respectively. The inside is exposed to gases at 1250 ^{o}C with a convection coefficient of 25 W/m^{2}.K. and the inside surface is at 1100 ^{o}C, the outside surface is exposed to air at 25 ^{o}C with convection coefficient of 12 W/m^{2}.K. Determine (a) the unknown thermal conductivity K (b) the overall heat transfer coefficient (c) all the intermediate temperatures?

2. Derive an expression for steady state temperature distribution in a slab with internal heat generation.

3. Dry air at 300 ^{0}C and 1 atm flows over a wet flat plate 600 mm. long at a velocity of 50 m/s. Calculate the mass transfer co-efficient of water vapour in air at the end of the plate. Take the diffusion co-efficient of water vapour in air, D = 0.26 x 10 -4 m^{2}/s.

Course Outcome 2 (CO2)

1. Discuss the importance of non-dimensional numbers in heat transfer problems.
2. A hollow sphere (k = 65 W/m.K) of 120 mm inner diameter and 350 mm outer diameter is covered 10 mm layer of insulation (k =10 W/m.K). The inside and outside temperatures are 500 °C and 50 °C respectively. Calculate the rate of heat flow through this sphere.

3. A steel ball (specific heat =0.46 kJ/kg.K, and thermal conductivity 35W/m.K) having 5 cm diameter and initially at a uniform temperature of 450 ^{o}C is suddenly placed in a control environment in which the temperature is maintained at 100 ^{o}C. Calculate the time required for the ball to attain a temperature of150 ^{o}C.

Course Outcome 3(CO3):

1. Water at the rate of 4 kg/s is heated from 40 ^{o}C to 55^{o}C in a shell and tube heat exchanger. On the shell side one pass is used with water as the heating fluid and at a mass flow rate of 2 kg/s, and entering the heat exchanger at 95 ^{o}C. The overall heat transfer coefficient is 1500 W/m^{2}K. and the average water velocity in the 2 cm diameter tubes is 0.5 m/s. Because of space limitations, the tube length must not exceed 3 m. Calculate the number of tube passes, the number of tubes per pass and the length of the tubes, keeping in mind the design constraints.

2. Two large plates, one at 800 K and other at 600 K have emissivities 0.5 and 0.8 respectively. A radiation shield having an emissivity 0.1 on one side and emissivity 0.05 on the other side is placed between the plates. Calculate the heat transfer by radiation per square meter with and without the radiation shield.

3. A rectangular aluminum fin of thermal conductivity 200 W/m.K, 3mm. thick and 7.5 cm long protrudes out from a wall. The fin base is maintained at a temperature of 300 ^{o}C and the ambient temperature is 50 ^{o}C with heat transfer coefficient 10W/m^{2}K. The tip of the fin is insulated. Calculate the heat transfer from the fin per unit depth of material.

Course Outcome 4 (CO4):

1. Explain velocity boundary layer and thermal boundary layer with neat sketches.

2. Air at 40 ^{o}C flows over a tube with a velocity of 30 m/s. The tube surface temperature is 120 ^{o}C. Calculate the heat transfer coefficient for the following cases:
   (i) Tube is square with a side of6 cm
   (ii) Tube is circular cylinder with a diameter of6 cm.

3. Air at 20 °C at atmospheric pressure flows over a flat plate at a velocity of 3 m/s. If the plate is 1 m wide and at 80 °C, calculate the following at x = 300mm.
   i. Hydrodynamic boundary layer thickness
   ii. Thermal boundary layer thickness
   iii. Local friction coefficient
   iv. Average heat transfer coefficient
   v. Heat transfer rate

MODEL QUESTION PAPER

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SIXTH SEMESTER MECHANICAL ENGINEERING

Heat and Mass Transfer-MET302

Maximum:100Marks **Duration: 3 hours**

PART A

Answer all questions. Each question carries 3 marks

1. Discuss about the application of Heisler chart and Schmidt plot in heat transfer analysis.
2. How does a numerical solution method differ from analytical one? Explain.
3. What are the characteristics of a boundary layer?
4. Write the significance of Nusselt number.
5. What is meant by condensation heat transfer? How it differs from drop wise heat transfer?
6. What are the main factors to be considered for a heat exchanger design?
7. Explain about radiation shape factor.
8. What are the properties of blackbody?
9. Give two examples of mass transfer in day-to-day life.
10. Explain Ficks law of diffusion with suitable assumptions.

(10 X 3 = 30 Marks)

PART B

Answer one full question from each module

MODULE 1

11.

a) Derive 3-dimensional unsteady state heat conduction equation with heat generation, in Cartesian co-ordinate system for anisotropic material. (7Marks)

b) A 3 mm diameter and 5m long electric wire is tightly wrapped with a 2 mm thick plastic cover whose thermal conductivity is k = 0.15 W/m-K. Electrical measurements indicate that a current of 10 A passes through the wire and there is a voltage drop of 8 V along the wire. If the insulated wire is exposed to a medium at T_∞ = 30°C with a heat transfer coefficient of h = 12 W/m²-K, determine the temperature at the interface of the wire and the plastic cover in steady operation. Also state with reason, whether doubling the thickness of the plastic cover will increase or decrease heat transfer.

(7 Marks)

12.

a) Derive an expression for temperature distribution for 1-dimensional slab with varying thermal conductivity. Assume the variation of thermal conductivity of slab as $k = k_0 (1+\beta t)$.

(7 Marks)

b) A square plate heater 15 cm x 15 cm is inserted between two slabs. Slab A is 2 cm thick (k = 50W/m-K) and Slab B is 1cm thick (k = 0.2W/m-K). The outside heat transfer coefficients on side A and side B are 200W/m²-K and 50W/m²-K respectively. The temperature of surrounding air is 25 °C. If rating of heater is 1 KW, find (a) Maximum temperature in the system, and (b) outer surface temperature of the two slabs. (7Marks)

MODULE II

13.

a) Saturated propane at 300 K with a velocity of 25 cm/s flows over a flat plate of length L=2 m. and width w=1 m. maintained at uniform temperature of 400 K. Calculate the local heat transfer coefficient at 1 m. length and the average heat transfer coefficient from L=0 m. to L=2 m. Also find the heat transfer. (7Marks)

b) Hot air at atmospheric pressure and 80°C enters an 8 m. long uninsulated square duct of cross section 0.2 m. x 0.2 m. that passes through the attic of a house at a rate of 0.15m³/s. The duct is observed to be nearly isothermal at 60°C. Determine the exit temperature of the air. (7Marks)

14.

a) Air at 15°C, 35 m/s, flows through a hollow cylinder of 4 cm. inner diameter and 6 cm. outer diameter and leaves at 45°C. The tube passes through a room where the room temperature is 65°C and tube wall is maintained at 60°C. Calculate the heat transfer coefficient between the air and the inner tube. (7Marks)

b) Consider a 0.6 m. x 0.6 m. thin square plate in a room at 30°C. One side of the plate is maintained at a temperature of 90°C, while the other side is insulated. Determine the rate of heat transfer from the plate by natural convection. If the emissivity of the surface is 1.0, calculate the heat loss by radiation. Also calculate the percentage of heat loss by convection. (7Marks)

MODULE III

15. 15.

a) A counter flow double pipe heat exchanger is to heat water from 20°C to 80°C at a rate of 1.2kg/s. The heating is to be accomplished by geothermal water available at 170°C at a mass flow rate of 2 kg/s. The inner tube is thin walled and has a diameter of 1.5 cm. If the overall heat transfer coefficient of the heat exchanger is 640 W/m^2-K, determine the length of the heat exchanger required to achieve the desired heating. Use ε-NTU method.

(8 Marks)

b) Derive an expression for LMTD of double pipe, parallel flow heat exchanger.

(6 Marks)

16. 16.

a) Steam in the condenser of a power plant is to be condensed at a temperature of 30°C with cooling water from a nearby lake, which enters the tubes of the condenser at 14°C and leaves at 22°C. The surface area of the tubes is 45 $m^2$and the overall heat transfer coefficient is 2100 W/m2 · °C. Determine the mass flow rate of the cooling water needed and the rate of condensation of the steam in the condenser. (7Marks)

b) In a double pipe heat exchanger, hot fluid with a specific heat of 2300 J/kg enters at 380°C and leaves at 300°C. Cold fluid enters at 25°C and leaves at 210°C. Calculate the heat exchanger area required for (i) Counter flow and (ii) Parallel flow. Take overall heat transfer coefficient as 750 W/m^2 K and mass flow rate of hot fluid is 1 kg/s. (7Marks)

MODULE IV

17. 17.

a) A 70 mm. thick metal plate with a circular hole of 35 mm. diameter along the thickness is maintained at a uniform temperature 250 ^oC. Find the loss of energy to the surroundings at 27 ^oC, assuming the two ends of the hole to be as parallel discs and the metallic surfaces and surroundings have blackbody characteristics. (6Marks)

b) Two large parallel planes with emissivities of 0.3 and 0.5 are maintained at temperatures of 527 ^0C and 127 ^0C respectively. A radiation shield having emissivities of 0.05 on both sides is placed between them. Calculate,

(i) Heat transfer rate between them without shield.

(ii) Heat transfer rate between them with shield.

(8 Marks)

18. 18.

a) Two parallel plates of size 1.0 m. by 1.0 m. spaced 0.5 m apart are located in a very large room, the walls of which are maintained at a temperature of 27^{0}C. One plate is maintained atatemperatureof900 ^{0}Candotherat400 ^{0}C.theiremissivity'sare0.2and 0.5 respectively. If the plates exchange heat between themselves and the surroundings, find the net heat transfer to each plate and to the room. Consider only the plate surface facing each other.

(8 Marks)

b) Two rectangular surfaces are perpendicular to each other with a common edge of 2 m. The horizontal plane is 2 m. long and vertical plane is 3 m long. Vertical plane is at 1200 K and has an emissivity of 0.4. the horizontal plane is 18 ^0C and has an emissivity of 0.3. Determine the net heat exchange between the planes. (6 marks)

MODULE V

19. 19.

a) Explain the analogy between heat and mass transfer. (6 Marks)

b) Dry air at 30^{0}C and 1 atm flows over a wet flat plate 600 mm. long at a velocity of 50 m/s. Calculate the mass transfer co-efficient of water vapour in air at the end of the plate. Take the diffusion co-efficient of water vapour in air, D = 0.26 x 10^{-4} m^2/s.

(8Marks)

20. 20.

a) Gaseous hydrogen is stored at elevated pressure in a rectangular steel container of 10 mm. wall thickness. The molar concentration of hydrogen in steel at the inner surface is 2 kg mol/m3, while the concentration of hydrogen in steel at the outer surface is 0.5 kg mol/m^3. The binary diffusion coefficient for hydrogen in steel is 0.26 x 10-12 m^2/s. What is the mass flux of hydrogen through the steel? (8 Marks)

b) Explain the phenomenon of equimolar counter diffusion. Derive an expression for equimolar counter diffusion between two gases or liquids.

(6 Marks)

Syllabus

Module 1-

CONDUCTION HEAT TRANSFER

Introduction to heat transfer- thermodynamics and heat transfer-typical heat transfer situations- modes of heat transfer- mechanism of heat transfer- basic laws of heat transfer- thermal conductivity-effect of temperature on thermal conductivity- combined heat transfer mechanism-real life situations of combined heat transfer.

Differential equations of heat conduction-boundary conditions and initial conditions, one dimensional steady state situations – plane wall, cylinder, sphere -concept of thermal resistance, critical radius, conduction with heat generation- Two-dimensional steady state situations, transient conduction, Lumped capacitance model, concept of Heisler chart and Schmidt Plot-Conduction shape factor-Numerical methods of analysis-thermal analysis of rectangular fins.

Module 2

CONVECTION HEAT TRANSFER

Fundamentals, order of magnitude analysis of momentum and energy equations; hydrodynamic and thermal boundary Layers-Relation between fluid friction and heat transfer-Concepts of fluid mechanics, Differential equation of heat convection, Laminar flow heat transfer in circular pipe – constant heat flux and constant wall temperature, thermal entrance region, Turbulent flow heat transfer in circular pipe, pipes of other cross sections, Heat transfer in laminar flow and turbulent flow over a flat plate, Reynolds analogy, Flow across a cylinder and sphere- Natural convection- basics-free convection heat transfer on a vertical flat plate-empirical relations for free convection heat transfer.

Module 3

HEAT EXCHANGERS

Condensation heat transfer phenomena- the condensation Number-Boiling heat transfer Phenomena-Simplified relations for boiling heat transfer-Introduction to heat exchangers-types of heat exchangers-the overall heat transfer coefficient-Fouling factor-LMTD analysis of heat exchangers- effectiveness-NTU method-Analysis of variable properties-compact heat exchangers-heat exchanger design considerations.

Module 4

RADIATION HEAT TRANSFER

Physical mechanism of radiation heat transfer-Radiation properties-; Black body radiation Planck's law, Wein's displacement law, Stefan Boltzmann law, Kirchoff's law; Gray body Radiation shape factors-heat exchange between non -black bodies-Infinite parallel planes-Radiation combined with conduction and convection.

Module 5

MASS TRANSFER

Introduction to mass transfer- Molecular diffusion in fluids- Steady state molecular diffusion in fluids under stagnant and laminar flow conditions - Fick's law of diffusion-Types of solid diffusion- mass transfer coefficients in laminar and turbulent flows- Introduction to mass transfer coefficient- Equimolar counter-diffusion- Correlation for convective mass transfer coefficient- Correlation of mass transfer coefficients for single cylinder- Theories of mass transfer- Overall mass transfer coefficients.

Text Books

1. Sachdeva R.C., Fundamentals of Engineering Heat and Mass Transfer, New Age Science Limited, 2009

2. R.K.Rajput. Heat and mass transfer, S.Chand &Co., 2015

3. Nag P.K., Heat and Mass Transfer, McGrawHill, 2011

4. Kothandaraman C.P., Fundamentals of Heat and Mass Transfer, New Age International, New Delhi,2006

Data Book

Heat and Mass Transfer data book: C.P. Kothandaraman, S. Subramanya, New age International Publishers,2014

Reference Books

2. Holman J.P, "Heat transfer", Mc Graw-Hill, 10th. Ed.,2009.

3. Yunus A. Cengel, "Heat and Mass Transfer: Fundamentals and Applications" McGraw-Hill Higher Education; 6th edition,2019.

4. Frank P. Incropera and David P. Dewitt, Heat and Mass Transfer, John Wiley and sons,2011

COURSE PLAN

MODULE	TOPICS	HOURS ALLOTED
1	Introduction to heat transfer- thermodynamics and heat transfer- typical heat transfer situations- modes of heat transfer- mechanism of heat transfer- basic laws of heat transfer- thermal conductivity- thermal conductivity-effect of temperature on thermal conductivity- combined heat transfer mechanism-real life situations of combined heat transfer.	2-0-0
	Differential equations of heat conduction-boundary conditions and initial conditions, one dimensional steady state situations – plane wall, cylinder, sphere -concept of thermal resistance, critical radius, conduction with heat generation- Two-dimensional steady state situations, transient conduction, Lumped capacitance model, concept of Heisler chart and Schmidt Plot-Conduction shape factor- Numerical methods of analysis- thermal analysis of rectangularfins.	6-4-0
2	Fundamentals, order of magnitude analysis of momentum and energy equations; hydrodynamic and thermal boundary Layers- Relation between fluid friction and heat transfer-Concepts of fluid mechanics, Differential equation of heat convection, Laminar flow heat transfer in circular pipe – constant heat flux and constant wall temperature, thermal entrance region, Turbulent flow heat transfer in circular pipe, pipes of other cross sections, Heat transfer in laminar flow and turbulent flow over a flat plate, Reynolds analogy, Flow across a cylinder and sphere- Natural convection- basics- free convection heat transfer on a vertical flat plate- empirical relations for free convection heattransfer.	6-4-0
3	Condensation heat transfer phenomena- the condensation Number- Boiling heat transfer Phenomena-Simplified relations for boiling heat transfer-Introduction to heat exchangers-types of heat exchangers-the overall heat transfer coefficient-Fouling factor- LMTD analysis of heat exchangers-effectiveness-NTU method- Analysis of variable properties- compact heat exchangers-heat exchanger design considerations.	5-2-0
4	Physical mechanism of radiation heat transfer-Radiation properties-; Black body radiation Planck’s law, Wein’s displacement law, Stefan Boltzmann law, Kirchoff’s law; Gray body Radiation shape factors- heat exchange between non -black bodies-Infinite parallel planes- Radiation combined with conduction and convection.	5-2-0

5	Introduction to mass transfer- Molecular diffusion in fluids- Steady state molecular diffusion in fluids under stagnant and laminar flow conditions - Fick’s law of diffusion-Types of solid diffusion- mass transfer coefficients in laminar and turbulent flows- Introduction to mass transfer coefficient- Equimolar counter-diffusion- Correlation for convective mass transfer coefficient- Correlation of mass transfer coefficients for single cylinder- Theories of mass transfer- Overall mass transfer coefficients	**7-2-0**

CODE MET304	COURSE NAME DYNAMICS AND DESIGN OF MACHINERY	CATEGORY	L	T	P	CREDIT
		PCC	3	1	0	4

Preamble: This course focuses on important topics of dynamics of machinery and design of machine elements. It covers the topics namely force of four bar mechanisms, design of flywheels, welded joints, riveted joints and spring. Design of machine elements due to impact, shock and fatigue loading are covered in the syllabus. Analysis of free and forced vibration of single degree of freedom systems and a brief introduction about free vibration of two degree of freedom systems is also included.

Prerequisite: EST100 Engineering Mechanics

Course Outcomes: After the completion of the course the student will be able to:

CO 1	Do engine force analysis and to draw turning moment diagrams
CO 2	Analyse free and forced vibrations of single degree of freedom systems
CO 3	Determine the natural frequencies of a two degree of freedom vibrating system and to calculate the stresses in a structural member due to combined loading
CO 4	Design machine elements subjected to fatigue loading and riveted joints
CO 5	Design welded joint and close coiled helical compression spring

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3	2									
CO 2	3	3	2									
CO 3	3	3	2									
CO 4	3	3	2									
CO 5	3	3	2									

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	10
Understand	20	20	20
Apply	20	20	70
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance	: 10 marks
Continuous Assessment Test (2 numbers)	: 25 marks
Assignment/Quiz/Course project	: 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Explain D' Alembert's principle.
2. Determine analytically the forces such as piston effort, force in the connecting rod and side thrust on the cylinder walls of a reciprocating engine.
3. Draw the turning moment diagram of IC engine.
4. Derive an expression for the coefficient of fluctuation of energy.
5. Derive an expression relating the stress in a flywheel and its linear speed.

Course Outcome 2 (CO2)

1. Explain the energy method and Newton's method to determine the natural frequencies of a single degree of freedom system.
2. Derive an expression for the logarithmic decrement.
3. Find the forced response of a damped single degree of freedom vibrating system subjected to a harmonic excitation.
4. Distinguish between motion transmissibility and force transmissibility.
5. What is whirling? Derive an expression for the critical speed of a shaft.

Course Outcome 3 (CO3):

1. Find the natural frequencies and mode shapes of a two degree freedom vibrating system.
2. What do you mean by eigenvalues and eigenvectors of a multi degree freedom vibrating system?
3. What are the steps in the design process?
4. Define stress concentration factor. How can we minimize it?

Course Outcome 4 (CO4):

1. Explain Goodman's criterion.

2. Explain Soderberg's criterion.
3. Define endurance limit and factor of safety.

4. Derive an expression for the impact stress due to a freely falling body.
5. Describe the modes of failure of a riveted joint.
6. What are the different efficiencies of a riveted joint?
7. Classify the riveted joints.

Course Outcome 5 (CO5):

1. What are the different types of welded joint?
2. Describe AWS welding symbols with neat sketches.
3. Determine the weld size of a joint subjected to axial, bending and twisting loads.
4. Derive an expression for the shear stress in the spring wire.
5. Derive an expression for the deflection of a helical compression spring.
6. Why concentric springs are required in certain applications?

MODEL QUESTION PAPER

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

VI SEMESTER BTECH DEGREE EXAMINATION

MET304 : DYNAMICS AND DESIGN OF MACHINERY

Maximum: 100 Marks   Duration:3 hours

Use of Machine Design Data Book is permitted.

PART A

Answer all questions, each question carries 3 marks

1. Describe briefly the dynamic force analysis of a reciprocating engine.
2. Derive an expression for the coefficient of fluctuation of energy.
3. Derive an expression for logarithmic decrement.
4. Define whirling speed of a shaft.
5. Explain the mode shapes of a vibrating system.
6. What are the steps in the design process?
7. Define endurance limit. What are the factors affecting it?
8. What are the failure modes of a riveted joint?

9. Describe the AWS welding symbols.

10. Explain i) surge ii) resilience and iii) curvature effect of a spring. (10×3=30 Marks)

PART B

Answer one full question from each module

MODULE 1

11. a) Describe with a neat sketch the turning moment diagram for a four-stroke internal combustion engine (4 marks)

b) The turning moment of an engine is given by the equation: 2500 + 750 sin 3θ Nm where θ is the crank angle in radians. The mean speed of the engine is 300 rpm. The flywheel along with other rotating parts attached to the engine have a mass of 500 kg at a radius of gyration of 0.8 m. Determine i) the power developed by the engine and ii) the percentage of fluctuation of speed of the flywheel (10 marks)

12. a) State and explain D' Alembert's principle. (4 marks)

b) The ratio of connecting rod length to crank length of a vertical gasoline engine is 4. The engine bore and stroke are 8 cm and 10 cm respectively. The mass of the reciprocating parts is 1 kg. The gas pressure on the piston is 6 bar, when it has moved 40° from the inner dead centre during the power stroke. Determine the following:

i. Net load on the piston
ii. Net load on the gudgeon pin and the crank pin
iii. Thrust on the cylinder walls
iv. Thrust on the crank bearing

The engine runs at 2000 rpm. At what engine speed will the net load on the gudgeon pin be zero? (10 marks)

MODULE 2

13. a) A machine of mass 1000 kg is acted upon by an external force of 2450 N at a speed of 1500 rpm. To reduce the effect, vibration isolators made of rubber having a static deflection of 2 mm under the machine load and an estimated damping factor of 0.2 are used. Determine the following:

i. Force transmitted to the foundation

ii. Amplitude of vibration of machine

iii. Phase lag between the transmitted force and the displacement of mass.

(9 marks)

b) Distinguish between motion transmissibility and displacement transmissibility. (5 marks)

14. a) A damped spring mass system has mass 3 kg, stiffness 100 N/m and damping coefficient 3 Ns/m. Determine the following:

i. Damping ratio

ii. Damped natural frequency

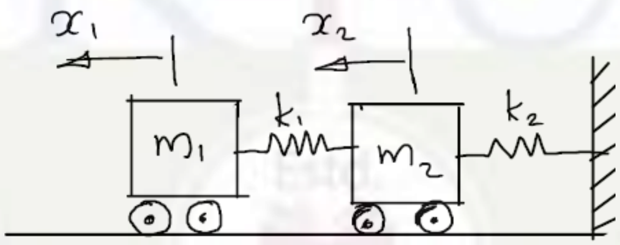
iii. Logarithmic decrement

iv. Ratio of two successive amplitudes (8 marks)

b) Describe briefly Newton's method and energy method used for obtaining the natural frequencies. (6 marks)

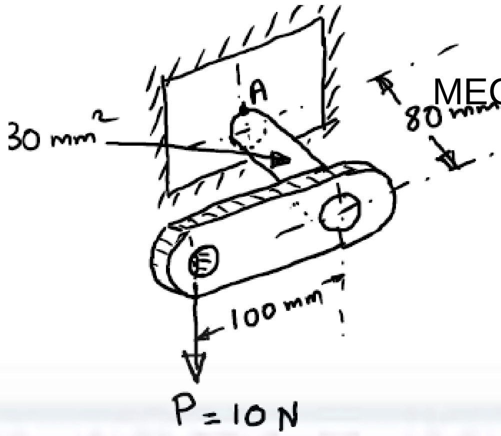
MODULE 3

15. Find the natural frequencies and mode shapes of a two degree freedom system shown in figure. The masses are m_1 = m_2 = 10 kg and the stiffness values are k_1=k_2=2 kN/mm.



16. a) Define stress concentration factor. How can it be minimized? (5 marks)

b) Calculate the stress at point A on the fixed end of a rod of length 80 mm and cross-sectional area 30 mm^2 shown in figure. (9 marks)



MODULE 4

17. a) Distinguish between Soderberg and Goodman criteria. (5 marks)

b) A round bar is subjected to the following variable loads. Torque varying from 2kNm to 5 kNm, bending moment varying from 10 kNm to 12 kNm. Calculate the size of the bar if it is made of C40 steel with yield stress of 324 MPa. Yield stress in shear is 50% of that in uniaxial loading. Adopt a factor of safety of 2.5 on yield stress for shear. (9 marks)

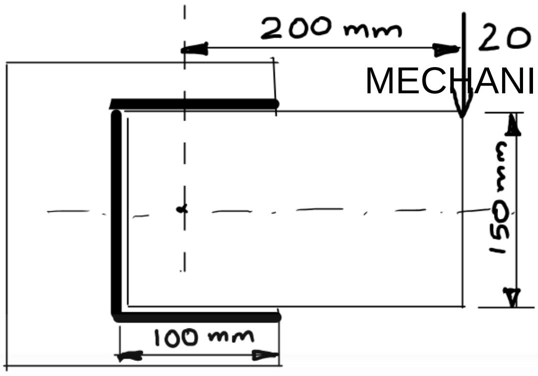
18. a) What are the advantages of riveted joint over welded joint? (4 marks)

b) Design a double riveted butt joint with equal widths of cover plates to join two plates of thickness 10 mm. The allowable stress for the material of the rivets and for the plates are as follows: For plate material in tension, σ_t = 80 MPa, for rivet material in compression, σ_c = 120 MPa, for rivet material in shear, τ = 60 MPa (10 marks)

MODULE 5

19. a) Describe with neat sketches the different types of welded joints. (5 marks)

b) An eccentrically loaded bracket is welded to a support as shown in figure. The permissible shear stress for the weld material is 80 MPa. Determine the size of the weld. (9 marks)



20. a) Derive an expression for the axial deflection of a close coiled helical spring.

(5 marks)

b) A bumper consisting of two helical springs of circular section, brings to rest a railway wagon of mass 1500 kg moving at 1.2 m/s. While doing so, the springs are compressed by 150 mm. The mean diameter of the coil is 6 times the wire diameter. The permissible shear stress is 400 MPa. Determine i) the maximum force on each spring ii) wire diameter of the spring, iii) mean diameter of the coils and iv) the number of active coils. Take G=0.84 x 10^6 MPa. (9 marks)

Syllabus

Module 1

Dynamic force analysis- D' Alembert's principle –four bar mechanism- engine force analysis (reciprocating engines)- piston side thrust-connecting rod force-piston effort- dynamic force analysis considering mass of the connecting rod-analytical method.

Flywheels-turning moment diagrams for four stroke internal combustion engine and multi cylinder engines-coefficient of fluctuation of speed-coefficient of fluctuation of energy-design of flywheels.

Module 2

Introduction- free vibration of single degree undamped systems- natural frequency-energy method- Newton's second law (free body diagram)-damped systems- logarithmic decrement.

Forced vibration-single degree of freedom systems-harmonic excitation-vibration isolation-transmissibility-whirling of shafts.

Module 3

Introduction to two degree of freedom systems- natural frequencies and mode shapes.

Introduction to design-definition, steps in the design process, materials and their properties-elastic and plastic behaviour of metals, ductile and brittle behaviour, shear, bending and torsional stresses, combined stresses, stress concentration factor.

Module 4

Shock and impact loads- fatigue loading- Gerber, Goodman and Soderberg criteria, endurance limit stress, factors affecting endurance limit, factor of safety.

Deign of riveted joints- material for rivets, modes of failure, efficiency of joint, design of boiler and tank joints, structural joints.

Module 5

Design of welded joints-welding symbols, stresses in fillet and butt welds, Butt joint in tension, fillet weld in tension, fillet joint under torsion, fillet weld under bending, eccentrically loaded welds.

Springs- classification, spring materials, stresses and deflection of helical springs, axial loading, curvature effect, resilience, static and fatigue loading, surge in spring, critical frequency, concentric springs, end construction.

Text Books

1. Ballaney, P. L. Theory of machines and mechanisms. Khanna Publishers, 2010.

2. Rattan S S, Theory of Machines, Tata McGraw-Hill Education, 2005.

3. Bhandari V B, Design of Machine Elements, Tata McGraw-Hill Education, 2010.

Design Data Books (permitted for reference in the university examination)

1. Mahadevan, K., and K. Balaveera Reddy. Design Data Handbook; Mechanical Engineers in SI and Metric Units. CBS Publishers & Distributors, New Delhi, 2018.
2. NarayanaIyengar B.R & Lingaiah K, Machine Design Data Handbook, Tata McGraw Hill/Suma Publications, 1984
3. PSG Design Data, DPV Printers, Coimbatore, 2012

Reference Books

1. Charles E Wilson and J Peter Sadler, Kinematics and Dynamics of Machinery, Tata McGraw-Hill Education, 2008.

2. Amithabha Ghosh and Asok Kumar Malik, Theory of Mechanisms and Machines, East West Press, 2011

3. Robert L Norton, Design of Machinery, Tata Mc Graw-Hill, 2005

4. P C Sharma and D K Aggarwal, Machine Design, S K Kataria & Sons

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1		
1.1	Dynamic force analysis- D' Alembert's principle –Four bar mechanism-	3
1.2	Engine force analysis (reciprocating engines)- piston side thrust-connecting rod force-piston effort- dynamic force analysis considering mass of the connecting rod-analytical method.	4
1.3	Flywheels, turning moment diagrams-four stroke internal combustion engines and multi cylinder engines	3
1.4	Coefficient of fluctuation of speed-coefficient of fluctuation of energy-design of flywheels	2
2		
2.1	Introduction- free vibration of single degree undamped systems-natural frequency-energy method- Newton's second law (free body diagram)-damped systems- logarithmic decrement.	3
2.2	Forced vibration-single degree of freedom systems-harmonic excitation-vibration isolation-transmissibility-whirling of shafts.	3
3		
3.1	Introduction to two degree of freedom systems- natural frequencies and mode shapes.	3
3.2	Introduction to design-definition, steps in design process. materials and their properties- elastic and plastic behaviour of metals, ductile and brittle behaviour	3
3.3	Shear, bending and torsional stresses, combined stresses, stress concentration factor.	4
4		
4.1	Shock and Impact loads, fatigue loading- Gerber, Goodman and Soderberg criteria, endurance limit stress, factors affecting endurance limit, factor of safety.	2
4.2	Deign of riveted joints- material for rivets, modes of failure, efficiency of joint, design of boiler and tank joints, structural joints.	3
5		
5.1	Design of welded joints-welding symbols, stresses in fillet and butt welds, butt joint in tension, fillet weld in tension,	3
5.2	Fillet joint under torsion, fillet weld under bending, eccentrically loaded welds.	2
5.3	Springs- classification, spring materials, stresses and deflection of	3

	helical springs, axial loading, curvature effect, resilience, static and fatigue loading	
5.4	Surge in spring, critical frequency, concentric springs, end construction.	3

MET 306	ADVANCED MANUFACTURING ENGINEERING	CATEGORY	L	T	P	Credits
		PCC	3	1	0	4

Preamble:

1. Understand the capabilities, limitations of conventional manufacturing &machining process and what the need of advanced manufacturing processes is.
2. Understand, how to formulate tool path and program CNC machines.
3. Understand, how PLC operate and control automated equipment and systems.
4. Understand the need of atomic level surface roughness and machining process.
5. Understand the need of high velocity forming of metals.

Prerequisite: MET 205 Metallurgy and material science and MET204 Manufacturing Processes

Course Outcomes - At the end of the course students will be able to

CO 1	To be conversant with the advanced machining process and to appreciate the effect of process parameters on the surface integrity aspects during the advanced machining process.
CO 2	CNC programming, select appropriate tooling and fixtures.
CO 3	To categorize the various nontraditional material removal process based on energy sources and mechanism employed.
CO 4	Analyze the processes and evaluate the role of each process parameter during micro machining of various advanced material removal processes.
CO 5	Explain the processes used in additive manufacturing for a range of materials and applications.

Mapping of course outcomes with program outcomes (Minimum requirements)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	-	-	-	2	-	-	-	-		-	2
CO 2	2	-	2	-	3	-	-	-	-	-	-	
CO 3	2	-		-	2	-	-	-	-	-	-	2
CO 4	2	3	-		2	-	-	-	-	-	-	-
CO 5	2		-	3	2	-	-	-	-	-	2	-

Assessment Pattern

Bloom's taxonomy	Continuous Assessment Tests		End Semester Examination (Marks)
	Test I (Marks)	Test II (Marks)	
Remember	25	25	25
Understand	15	15	15
Apply	30	25	30
Analyze	10	10	10
Evaluate	10	15	10
Create	10	10	10

Mark distribution

Total Marks	CIE marks	ESE marks	ESE duration
150	50	100	3 Hours

Continuous Internal Evaluation (CIE) Pattern:

Attendance	10 marks
Regular class work/tutorials/assignments/self-learning (Minimum 3numbers)	15 marks
Continuous Assessment Test(Minimum 2numbers)	25 marks

End semester pattern: -There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have maximum 2 sub-divisions and carry 14 marks.

COURSE LEVEL ASSESSMENT QUESTIONS

Course Outcome 1 (CO1): - To be conversant with the advanced machining process and to appreciate the effect of process parameters on the surface integrity aspects during the advanced machining process.

1. How carbonyls are useful in powder metallurgy?
2. A simple integrator in which p is a constant is performed with a DDA integrator. Calculate the output Δz at the first 8 iterations. The DDA contains 3-bit register which are initially set p =5 and q=0. If each iteration is executed in 1 ms, draw the accumulated output Δz versus time.

3. What are the process parameters affecting the performance of USM

4. Draw and explain the effect of high speed on stress strain relationship of mild steel and copper

Course Outcome 2 (CO2): CNC programming, select appropriate tooling and fixtures.

1. Draw relay ladder diagram for the following sequential operations. Start button pressed, table motor started, package moves to the position of the limit switch and stops. Auxiliary features required are emergency stop, red light to indicate stop condition and green light to indicate package moving condition. Draw input and output connection diagrams also.
2. Draw a PLC ladder logic diagram to get the reciprocating motion of a punching machine using following sequential operations. One of the two motors operates when power is supplied. Motor drives the punch to one side. When it completes the required movement in one direction, a limit switch detects the position of the punch. First motor is get deactivated. Second motor starts and moves the punch to the opposite direction. When it completes required movement in opposite direction, a second limit switch detects the position of the punch. Second motor is get deactivated and first motor is started again and the process continues so as to get a continuous reciprocating motion. Also draw the input and output diagrams.
3. A DDA contains 8 bit registers. The value of its *p* register is constant and P=150 and the clock frequency is 10240pps. Calculate the output frequency of DDA
4. Describe with sketch the working and construction of recirculating ball screw used in CNC machine tools.
5. Explain linear and circular interpolations used in turning. Draw a neat sketch of circular interpolation

Course Outcome 3 (CO3): To categorize the various nontraditional material removal process based on energy sources and mechanism employed.

1. How the amplitude and frequency of vibration effects on material removal rate in Ultra Sonic Machining
2. What are the functions of electrolyte in ECM? What are the properties to be considered while selecting electrolytes in ECM?
3. What are the process parameters affecting the performance of USM

4. Which are the factors affecting its MRR in IBM process.
5. Describe the mechanism of material removal in Ion beam machining

Course Outcome 4 (CO4): Analyze the processes and evaluate the role of each process parameter during micro machining of various advanced material removal processes.

1. What is magneto rheological lapping? What are its advantages over conventional lapping?
2. Ablation of metals with Ultra short laser pulses.
3. Explain different types of elastic body waves
4. Draw and explain the effect of high speed on stress strain relationship of mild steel and copper
5. Explain with a neat schematic the fundamental principle of material removal in an abrasive jet machiningprocess. Plot the trend for the Material Removal Rate with Nozzle Tip Distance (NTD) and explain why it rises,platues and falls with increasing NTD.
6. What is meant by ductile regime machine?

Course Outcome 5 (CO5): Explain the processes used in additive manufacturing for a range of materials and applications.

1. What are the two materials that are most commonly used for doing rapid prototyping of parts
2. What are themajor process parameters the involved in LIGA process?
3. A new car is designed, incorporating new technology, suggest how rapid prototyping could be applied for the development of the product. what are the steps followed? Discuss the factors considered.

MODEL QUESTION PAPER
SIXTH SEMESTER MECHANICAL ENGINEERING
MET 306 - ADVANCED MANUFACTURING ENGINEERING

Maximum Marks: 100 **Duration: 3 Hours**

Part – A

Answer all questions, each question carries 3 marks

1. Explain the different stages of sintering process in Powder metallurgy
2. Differentiate the impregnation and infiltration process in Powder metallurgy
3. What are the different word address formats used in part programming?
4. Mention the purpose of miscellaneous functions in part programming. Write any 2 M –codes with their applications
5. Describe the mechanism of material removal in Ion beam machining
6. What are the functions and desirable properties of dielectric fluid in EDM?
7. Explain the two Techniques in Explosive forming process
8. Differentiate P wave and S wave in High Velocity Forming
9. Write a note on Elastic Emission Machining
10. Explain the LIGA and its application, what is the aspect ratio in LIGA.

PART -B

Answer one full question from each module.

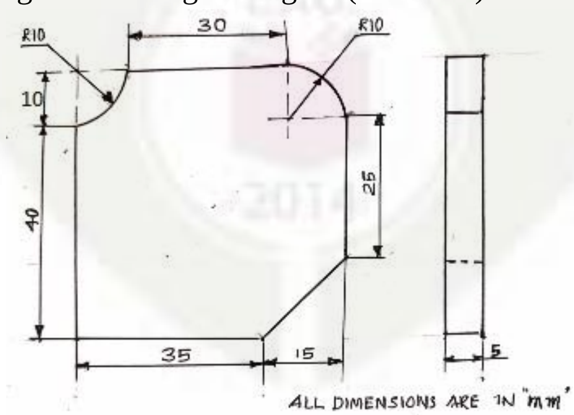
MODULE – 1

11. a) Explain the need and comparison between traditional and non-traditional manufacturing processes. (7 marks).

12. Explain Merchant's theory with neat sketches. (14 marks).

MODULE – 2

Write a Manual Part Program for the given figure (14 marks).



13. What is meant by interpolation in NC systems? Explain different types of interpolations. (14marks)

MODULE – 3

14. a) What are the parameters influencing the MRR in USM process (7 marks).
b) How LBM differs from and EBM (7 marks).

15. Explain IBM with neat sketch; applications and vividly the process parameters influencing on it (14marks).

16.

MODULE – 4

a) Compare high velocity forming with conventional forming process (7 marks).

b) What are stress waves? Write the equation for finding the velocity of shear wave (7 marks).

17. Explain Electro Magnetic Forming and show that it can be applied to internal, external and surface forming operations. (14 marks).

MODULE – 5

18. a.Explain the material removal mechanism in Diamond turn machining process (7 marks).
b. With a neat sketch explain Diamond turn machining process. (7 marks).

19. . a. With a neat sketch explain Selective Laser Sintering.(7 marks).
20. b.Describe the Laminated Object Manufacturing Process (7 marks).

SYLLABUS

Module I

Powder Metallurgy- Powder Production- Powder characteristics- Mixing – Compaction: -techniques- sintering- Theory metal cutting - Orthogonal and oblique cutting- chip formation- Merchant’s theory-Friction force - cutting tool materials -Thermal aspects of machining -Tool wear and wear mechanisms - Economics of machining- Machinability- Cutting fluids.

Module II

Programmable Logic Controllers (PLC) – CNC: systems - contouring systems: principle of operation -DDA integrator: -Principle of operation, exponential deceleration –liner, circular and complete interpolator - NC part programming - Computer aided part programming - machining centers, feedback devices.

Module III

Non Traditional machining processes: - EDM, USM, ECM, LBM, EBM, PAM, IBM, AJM, AWJM.

Module IV

High velocity forming of metals - Sheet metal forming - explosive forming - Electro hydraulic forming - Electro Magnetic Forming.

Module V

Micromachining: Diamond turn mechanism, Advanced finishing processes: - Abrasive Flow Machining, Magnetic Abrasive Finishing. - Magnetorheological Finishing, Magnetorheological Abrasive Flow Finishing, Magnetic Float Polishing, Elastic Emission Machining. - Material addition processes: - stereo-lithography, selective laser sintering, fused deposition modeling, laminated object manufacturing, laser engineered net-shaping, laser welding, LIGA process.

Text Books

1. YoramKoren, Computer control of manufacturing systems, TMH
2. Jain V.K., Introduction to Micromachining, Narosa publishers.
3. Davies K and Austin E.R, Developments in high speed metal forming, the machinery publishing Co, 1970, SBN -853332053

Reference

1. ASTME, High velocity forming of metals, PHI, 1968.
2. Ibrahim Zeid, R Sivasubrahmanian CAD/CAM: Theory & Practice Tata McGraw Hill Education Private Limited, Delhi.
3. .P.Groover, E.M. Zimmers, Jr.”CAD/CAM”; Computer Aided Design and Manufacturing, Prentice Hall of India, 1987
4. PetruzellaFrank.D. - Programmable logic controllers
5. Jain V.K., Advanced Machining Processes
6. Armarego and Brown, The Machining of Metals, Prentice – Hall.
7. Paul. H. Black, Theory of Metal Cutting, McGraw Hill.
8. ASM hand book Volume 16, Machining, ASM international, 1989
9. Lal G.K., Introduction to Machining Science, New Age Publishers.

COURSE CONTENT AND LECTURE SCHEDULES.

Module	TOPIC	No.of hours	Course outcomes
1.1	Introduction: Need and comparison between traditional, non-traditional and micro &nano machining process.	2	CO1
	Powder Metallurgy: Need of P/M - Powder Production methods:- Atomization, electrolysıs, Reduction of oxides, Carbonyls (Process parameters, characteristics of powder produced in each method).		
1.2	Powder characteristics: properties of fine powder, size, size distribution, shape, compressibility, purity etc.	2	CO1
	Mixing – Compaction:- techniques, pressure distribution, HIP & CIP(fundamentals to be explained in the class, self-learning topic , discretion of faculty)..		
1.3	Mechanism of sintering, driving force for pore shirking, solid and liquid phase sintering - Impregnation and Infiltration Advantages, disadvantages and specific applications of P/M.	1	
1.4	Theory metal cutting in turning: Tool nomenclature, attributes, surface roughness obtainable - Orthogonal and oblique cutting - Mechanism of metal removal - Mechanism of chip formation –chip breakers – Merchant’s theory.	3	CO1
1.5	Friction force laws in metal cutting - development of cutting tool materials (fundamentals to be explained in the class, self-learning topic, discretion of faculty).	1	CO1
1.6	Thermal aspects of machining -Tool wear and wear mechanisms - Economics of machining, Machinability, Cutting fluids(fundamentals to be explained in the class, self-learning topic, discretion of faculty).	1	CO1
2.1	Programmable Logic Controllers (PLC):need – relays - logic ladder program –timers, simple problems only.	1	CO1 CO2
2.2	Point to point, straight cut and contouring positioning - incremental and absolute systems – open loop and closed loop systems - control loops in contouring systems: principle of operation -DDA integrator:-Principle of operation, exponential deceleration –liner, circular and complete interpolator.	3	
2.3	NC part programming: part programming fundamentals - manual programming –NC coordinate systems and axes – tape format – sequence number, preparatory functions, dimension words, speed word, feed world, tool world, miscellaneous functions –	2	CO1 CO2
2.4	Computer aided part programming:– CNC languages – APT language structure.	3	CO1

	Programming exercises: simple problems on turning and drilling etc - (***At least one programming exercise must be included in the end semester University examination).*** - machining centers, feedback devices (fundamentals to be explained in the class, self-learning topic, discretion of faculty).		CO2
3.1	Non Traditional machining processes:- Electric Discharge Machining (EDM):- Mechanism of metal removal, dielectric fluid, spark generation, recast layer and attributes of process characteristics on MRR, accuracy, HAZ etc, Wire EDM, applications and accessories.	2	CO1 CO3
	Ultrasonic Machining (USM):-mechanics of cutting, effects of parameters on amplitude, frequency of vibration, grain diameter, slurry, tool material attributes and hardness of work material, applications.	2	CO1 CO3
3.2	Electro chemical machining (ECM):- Mechanism of metal removal attributes of process characteristics on MRR, accuracy, surface roughness etc, application and limitations.	1	CO1 CO3
3.3	Laser Beam Machining (LBM), Electron Beam Machining (EBM), Plasma arc Machining (PAM), Ion beam Machining(IBM) - Mechanism of metal removal, attributes of process characteristics on MRR, accuracy etc and structure of HAZ compared with conventional process; application, comparative study of advantages and limitations of each process.	3	CO1 CO3
3.4	Abrasive Jet Machining (AJM), Abrasive Water Jet Machining (AWJM) - Working principle, Mechanism of metal removal, Influence of process parameters, Applications, Advantages & disadvantages.	1	CO1 CO3
4.1	High velocity forming of metals:-effects of high speeds on the stress strain relationship steel, aluminum, Copper – comparison of conventional and high velocity forming methods- deformation velocity, material behavior, stain distribution.	2	CO1 CO3
4.2	Stress waves and deformation in solids – types of elastic body waves- relation at free boundaries- relative particle velocity.	2	CO1 CO3
4.3	Sheet metal forming: - explosive forming:-process variable,properties of explosively formed parts, etc.	2	CO1 CO3
4.4	Electro hydraulic forming: - theory, process variables, etc, comparison with explosive forming -Electro Magnetic Forming.	2	CO1 CO3
5.1	Micromachining: Diamond turn mechanism, material removal mechanism, applications.- Advanced finishing processes: - Abrasive Flow Machining, Magnetic Abrasive Finishing.	3	CO1 CO4
5.2	Magnetorheological Finishing, Magnetorheological Abrasive Flow Finishing, Magnetic Float Polishing, Elastic Emission Machining.	3	CO4
5.3	Material addition process**:-** stereo-lithography, selective laser sintering, fused deposition modeling, laminated object manufacturing, laser engineered net-shaping, laser welding, LIGA process.	3	CO5

MET308	COMPREHENSIVE COURSE WORK	CATEGORY	L	T	P	CREDIT
		PCC	1	0	0	1

Preamble: The course is designed to ensure that the students have firmly grasped the foundational knowledge in Mechanical Engineering familiar enough with the technological concepts. It provides an opportunity for the students to demonstrate their knowledge in various Mechanical Engineering subjects.

Pre-requisite: Nil

Course outcomes: After the course, the student will able to:

CO1	Learn to prepare for a competitive examination
CO2	Comprehend the questions in Mechanical Engineering field and answer them with confidence
CO3	Communicate effectively with faculty in scholarly environments
CO4	Analyze the comprehensive knowledge gained in basic courses in the field of Mechanical Engineering

Mapping of course outcomes with program outcomes:

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	2										2
CO 2	3	2										2
CO 3	3	2										2
CO 4	2	3										2

Assessment pattern

Bloom's Category	End Semester Examination (Marks)
Remember	25
Understand	15
Apply	5

Analyze	5
Evaluate	
Create	

End Semester Examination Pattern:

A written examination will be conducted by the University at the end of the sixth semester. The written examination will be of objective type similar to the GATE examination. Syllabus for the comprehensive examination is based on following five Mechanical Engineering core courses.

MET203- MECHANICS OF FLUIDS

MET205- METALLURGY AND MATERIAL SCIENCE

MET202- ENGINEERING THERMODYNAMICS

MET204– MANUFACTURING PROCESS

MET301- MECHANICS OF MACHINERY

The written test will be of 50 marks with 50 multiple choice questions (10 questions from each module) with 4 choices of 1 mark each covering all the five core courses. There will be no negative marking. The pass minimum for this course is 25. The course should be mapped with a faculty and classes shall be arranged for practicing questions based on the core courses listed above.

Written examination: 50marks

Total : 50 marks

Course Level Assessment and Sample Questions:

1. The shear stress developed in lubricating oil, of viscosity 9.81 poise, filled between two parallel plates 1cm apart and moving with relative velocity of 2 m/s is
   (a) 20 N/m^2
   (b) 19.62 N/m^2
   (c) 29.62 N/m^2
   (d) 40 N/m^2
2. For a Newtonian fluid
   (a) Shear stress is proportional to shear strain
   (b) Rate of shear stress is proportional to shear strain
   (c) Shear stress is proportional to rate of shear strain

(d) Rate of shear stress is proportional to rate of shear strain

3. Atomic packing factor (APF) in the case of copper crystal is
   (a) 0.52
   (b) 0.68
   (c) 0.74
   (d) 1.633
4. What is the approximate strain energy expression for a dislocation of unit length, irrespective of its edge or screw character?
   (a) $G^2b/2$
   (b) $Gb^2/2$
   (c) $G^2b/4$
   (d) $Gb^2/4$
5. Consider the following statements
   1. Zeroth law of thermodynamics is related to temperature
   2. Entropy is related to first law of thermodynamics
   3. Internal energy of an ideal gas is a function of temperature and pressure
   4. Van der Waals' equation is related to an ideal gas
   Which of the above statements is/are correct?
   (a) 1 only
   (b) 2, 3 and 4
   (c) 1 and 3
   (d) 2 and 4
6. A gas is compressed in a cylinder by a movable piston to a volume one-half of its original volume. During the process, 300 kJ heat left the gas and the internal energy remained same. What is the work done on the gas?
   (a) 100 kNm
   (b) 150 kNm
   (c) 200 kNm
   (d) 300 kNm
7. Which one of the following casting processes is best suited to make bigger size hollow symmetrical pipes?
   (a) Die casting
   (b) Investment casting
   (c) Shell moulding
   (d) Centrifugal casting
8. In gas welding of mild steel using an oxy-acetylene flame, the total amount of acetylene consumed was 10 litre. The oxygen consumption from the cylinder is
   (a) 5 litre
   (b) 10 litre
   (c) 15litre
   (d) 20 litre
9. The number of inversions for a slider crank mechanism is

   (a) 6 (b) 5 (c) 4 (d) 3

10. Total number of instantaneous centers for a mechanism with n links are

(a) n/2 (b) n (c) (n- 1) / 2 (d) (n(n-1)) /2

Syllabus

MODULE 1

Fluids and continuum, Physical properties of fluids, Newton's law of viscosity. Ideal and real fluids, Newtonian and non-Newtonian fluids. Fluid Statics- Pressure-density-height relationship, manometers, pressure on plane and curved surfaces, center of pressure, buoyancy, stability of immersed and floating bodies

Kinematics of fluid flow: Eulerian and Lagrangian approaches, classification of fluid flow, stream lines,path lines, streak lines, stream tubes, , stream function and potential function

Equations of fluid dynamics: Differential equations of mass, energy and momentum (Euler's equation), Bernoulli's equation, Pipe Flow: Viscous flow: shear stress and velocity distribution in a pipe Hagen Poiseuille equation. Darcy-Weisbach equation,

MODULE 2

Development of atomic structure - Primary bonds: - characteristics of covalent, ionic and metallic bond - properties based on atomic bonding Crystallography: - SC, BCC, FCC, HCP structures, APF , Miller Indices: - crystal plane and direction - Modes of plastic deformation: - Slip and twinning

Classification of crystal imperfections - forest of dislocation, role of surface defects on crack initiation- Burgers vector –Frank Read source - Correlation of dislocation density with strength and nano concept - high and low angle grain boundaries– driving force for grain growth and applications

Phase diagrams: - need of alloying - classification of alloys - Hume Rothery`s rule – equilibrium diagram of common types of binary systems: five types - Coring - lever rule and Gibb`s phase rule - Reactions- Detailed discussion on Iron-Carbon equilibrium diagram with micro structure and properties -Heat treatment: - TTT, CCT diagram, applications - Tempering- Hardenability, Jominy end quench test, applications- Surface hardening methods.

MODULE 3

Basic Thermodynamic Concepts Macroscopic and Microscopic viewpoints, Concept of Continuum, Thermodynamic System and Control Volume, Surrounding, Boundaries, Types of Systems, Universe, Thermodynamic properties, Process, Cycle, Thermodynamic Equilibrium, Quasi – static Process, State, Point and Path function. Zeroth Law of Thermodynamics, Measurement of Temperature, reference Points, Temperature Scales.

First law of Thermodynamics - First law applied to Non flow and flow Process- SFEE

Second Law of Thermodynamics, Kelvin-Planck and Clausius Statements, Equivalence of two statements Entropy- Entropy changes in various thermodynamic processes, principle of increase of entropy and its applications,Available Energy, Availability and Irreversibility- Second law efficiency.

MODULE 4

Casting:-Characteristics of sand - patterns- cores- -chaplets- simple problems- solidification of metals and Chvorinov's rule - Elements of gating system- risering -chills

Welding:-welding metallurgy-heat affected zone- grain size and hardness- stress reliving- joint quality -heat treatment of welded joints - weldability - destructive and non destructive tests of welded joints Thermit welding, friction welding - Resistance welding, Arc Welding, Oxyacetyline welding

Rolling:- principles - types of rolls and rolling mills - mechanics of flat rolling-Defects-vibration and chatter - flat rolling -miscellaneous rolling process

Forging: methods analysis, applications, die forging, defects in forging

MODULE 5

Introduction to kinematics and mechanisms - various mechanisms, kinematic diagrams, degree of freedom- Grashof’s criterion, inversions, coupler curves mechanical advantage, transmission angle. straight line mechanisms exact, approximate. Displacement, velocity analysis– relative motion - relative velocity. Instantaneous centre -Kennedy’s theorem.

Acceleration analysis- Relative acceleration - Coriolis acceleration - graphical and analytical methods.
Cams - classification of cam and followers - displacement diagrams, velocity and acceleration analysis of SHM, uniform velocity, uniform acceleration, cycloidal motion
Graphical cam profile synthesis, pressure angle.

MEL332	COMPUTER AIDED DESIGN & ANALYSIS LAB	CATEGORY	L	T	P	CREDITS
		PCC	0	0	3	2

Preamble:

- To introduce students to the basics and standards of engineering design and analysis related to machine components.
- To make students familiarize with different solid modelling and analysis soft wares
- To convey the principles and requirements ofmodelling and analysis of machine elements.
- To introduce the preparation of part modelling and assembly modelling of machineries
- To introduce standard CAD packages to perform Finite Element Analysis of machine parts

Prerequisite:

EST 110 - Engineering Graphics

MEL 201 - Computer Aided Machine Drawing

Course Outcomes - At the end of the course students will be able to

CO1	Gain working knowledge in Computer Aided Design and modelling procedures.
CO2	Gain knowledge in creating solid machinery parts.
CO3	Gain knowledge in assembling machine elements.
CO4	Gain working knowledge in Finite Element Analysis.
CO5	Solve simple structural, heat and fluid flow problems using standard software

Mapping of course outcomes with program outcomes (Minimum requirements)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	-	-	-	-	-	-	-	-	2	-	-
CO2	3	-	1	-	-	-	-	-	-	3	-	-
CO3	3	3	-	-	-	-	-	-	2	2	-	-
CO4	3	1	3	-	-	-	-	1	2	3	-	-
CO5	3	3	2	-	-	-	-	2	3	3	-	-

Mark Distribution

Total Marks	CIE Marks	ESE marks	ESE duration
150	75	75	2.5 hours

Continuous Internal Evaluation (CIE) Pattern:

Attendance	15 marks
Regular class work/Modelling and Analysis/Lab Record and Class Performance	30 marks
Continuous Assessment Test (minimum two tests)	30 marks

Continuous Assessment test pattern

Bloom's Taxonomy	Continuous Assessment Tests	
	Test 1 - PART A MODELLING (marks)	Test 2 - PART B ANALYSIS (marks)
Remember	10	10
Understand	10	10
Apply	20	20
Analyse	15	15
Evaluate	20	20
Create	25	25

End semester examination pattern

End semester examination shall be conducted on modelling and analysis and based on complete syllabus. The following general guidelines should be maintained for the award of marks

Part A Assembly Modelling – 35 marks
Part B Analysis – 30 marks
Viva Voce – 10 marks.

Conduct of University Practical Examinations

The Principals of the concerned Engineering Colleges with the help of the Chairmen/Chairperson will conduct the practical examination with the approval from the University and bonafide work / laboratory record, hall ticket, identity card issued by college are mandatory for appearing practical University examinations. No practical examination should be conducted without the presence of an external examiner appointed by the University.

References Books:

1. Daryl Logan, A First course in Finite Element Method, Thomson Learning, 2007
2. David V Hutton, Fundamentals of Finite Element Analysis, Tata McGraw Hill,2003
3. Ibrahim Zeid, CAD/ CAM Theory and Practice, McGraw Hill, 2007
4. Mikell P. Groover and Emory W. Zimmer, CAD/ CAM – Computer aided design and manufacturing, Pearson Education,1987
5. T. R. Chandrupatla and A. D. Belagundu, Introduction to Finite Elements in Engineering, Pearson Education, 2012

Experiment List (Minimum 12 exercises)

SL.NO	PART - A (Minimum 6 models)	COURSE OUTCOMES	HOURS
1	Creation of high end part models (minimum 2 models, Questions for examinations must not be taken from this portions)	CO1, CO2	6
2	Creating assembly models of Socket and spigot joint, Knuckle Joint, Rigid flange couplings, Bushed Pin flexible coupling, Plummer block, Single plate clutch and Cone friction clutch. Pipe joints, Screw jack, Tail stock etc. (minimum 4 models)	CO1, CO2, CO3	12
	PART – B (Minimum 6 problems)		
3	Structural analysis. (minimum 3 problems)	CO4, CO5	6
4	Thermal analysis. (minimum 2 problems)	CO4, CO5	3
5	Fluid flow analysis. (minimum 1 problem)	CO4, CO5	3

MECHANICAL ENGINEERING

END SEMSTER EXAMINATION

MODEL QUESTION PAPER

MEL332: COMPUTER AIDED DESIGN AND ANALYSIS LAB

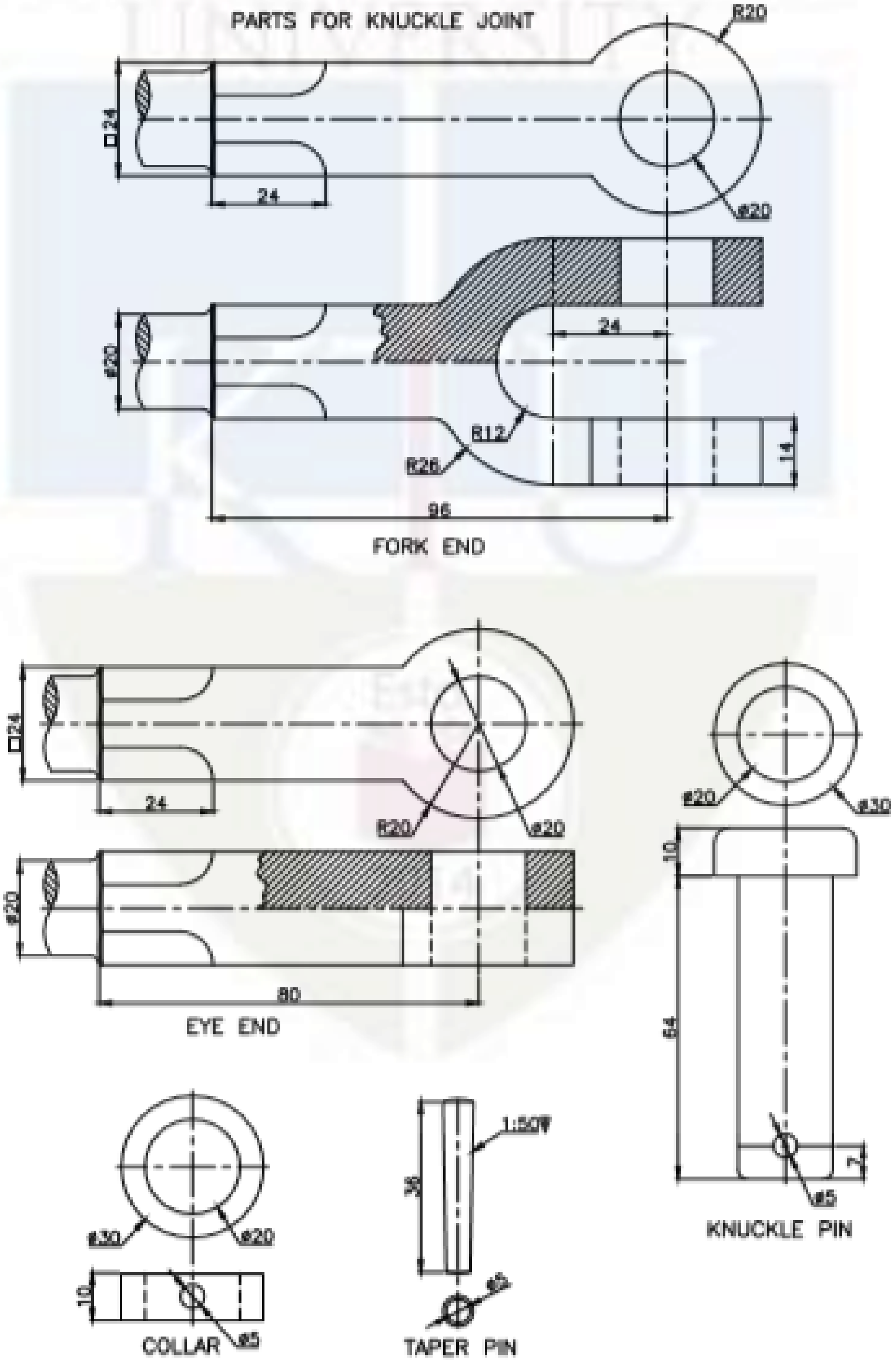
Duration : 2.5 hours Marks : 75

<u>Note :</u>

1. All dimensions in mm
2. Assume missing dimensions appropriately
3. A4 size answer booklet shall be supplied
4. Viva Voce shall be conducted for 10 marks

PART A (ASSEMBLY MODELLING) – 35 marks

1. Create an assembly model using the part details given below



PART B (FINITE ELEMENT ANALYSIS) – 30 marks

2. Air flows over a long cylinder of 150mm diameter at a velocity of 3m/sec at a temperature of 105º F. Using this data and applying finite element technique find
    a. Max velocity
    b. Plot flow trajectories
    c. Cut plot of velocity

MEL334	THERMAL ENGINEERING LAB-II	CATEGORY	L	T	P	CREDIT
		PCC	0	0	3	2

Preamble: The course is intended to enable the students to get exposed to equipment related to heat and mass transfer. This includes understanding the working of equipments related to various heat transfer processes viz conduction, convection, radiation and mass transfer. These equipments are heat exchangers, refrigeration and air conditioning systems, compressor/blower and their applications in real life problems. Also the thermo physical properties of materials which are integral to these equipments will also be evaluated. Apart from this, calibration of various instruments which are essential to these equipments will be done.

Prerequisite: Should have undergone a course on Heat and Mass Transfer

Course Outcomes: After the completion of the course the student will be able to

CO 1	Evaluate thermal properties of materials in conduction, convection and radiation
CO 2	Analyse the performance of heat exchangers
CO 3	Illustrate the operational performances of refrigeration and air conditioning systems
CO 4	Perform calibration of thermocouples and pressure gauges

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	**3**		2	3			2		3	2		2
CO 2	**3**		2	3			2		3	2		2
CO 3	**3**		2	3			2		3	2		2
CO 4	**3**		2	3			2		3	2		2

Assessment Pattern

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	75	75	2.5 hours

Continuous Internal Evaluation Pattern:

Attendance	:	15 marks
Continuous Assessment	:	30 marks
Internal Test (Immediately before the second series test)	:	30 marks

End Semester Examination Pattern: The following guidelines should be followed regarding award of marks

(a) Preliminary work	: 15 Marks
(b) Implementing the work/Conducting the experiment	: 10 Marks
(c) Performance, result and inference (usage of equipments and trouble shooting)	: 25 Marks
(d) Viva voce	: 20 marks
(e) Record	: 5 Marks

General instructions:

Practical examination is to be conducted immediately after the second series test covering entire syllabus given below. Evaluation is a serious process that is to be conducted under the equal responsibility of both the internal and external examiners. The number of candidates evaluated per day should not exceed 20. Students shall be allowed for the University examination only on submitting the duly certified record. The external examiner shall endorse the record.

Reference Books

1. Yunus A. Cengel, “Heat Transfer a Practical Approach”, Tata McGraw-Hill Education, 4th Edition, 2012.
2. R. C. Sachdeva, “Fundamentals of Engineering, Heat and Mass Transfer”, New Age publication, 3 rd Edition, 2012.
3. Holman J.P, “Heat transfer”, Mc Graw-Hill, 10th. Ed., 2009
4. Frank P. Incropera and David P. Dewitt, Heat and Mass Transfer, John Wiley and sons, 2011
5. Kothandaraman, C.P., Fundamentals of Heat and Mass Transfer, New Age International, New Delhi, 2006

List of Exercises/Experiments: (Lab experiments may be given considering 12 sessions of 3 hours each. Minimum 12 experiments to be performed.)

1. Determination of LMTD and effectiveness of parallel flow, Counter flow and cross flow heat exchangers
2. Performance studies on a shell and tube heat exchanger
3. Development of heat transfer correlation for heat exchangers/condenser using modified Wilson Plot Method
4. Determination of heat transfer coefficients in free convection
5. Determination of heat transfer coefficients in forced convection
6. Determination of thermal conductivity of solids (composite wall/metal rod)
7. Determination of thermal conductivity of powder
8. Determination of thermal conductivity of liquids
9. Measurement of unsteady state conduction heat transfer
10. Determination of emissivity of a specimen
11. Determination of Stefan Boltzman constant
12. Measurement of solar radiation
13. Experimental study of dropwise and filmwise condensation
14. Experiments on boiling heat transfer
15. Study and performance test on refrigeration (Refrigeration Test rig)
16. Study and performance test on air conditioning equipment (Air Conditioning test rig)
17. Performance study on heat pipe
18. Calibration of Thermocouples
19. Calibration of Pressure gauge

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
MET 312	NON DESTRUCTIVE TESTING	PEC	2	1	0	3

Preamble:

Nondestructive Testing (NDT) plays an extremely important role in quality control, flaw detection and structural health monitoring covering a wide range of industries. There are varieties of NDT techniques in use. This course will first cover the fundamental science behind the commonly used NDT methods to build the basic understanding on the underlying principles. It will then go on to cover the process details of each of these NDT methods.

Prerequisite: NIL

Course Outcomes: After the completion of the course the student will be able to

CO 1	Have a basic knowledge of surface NDT which enables to carry out various inspections in accordance with the established procedures.
CO 2	The students will be able to differentiate various defect types and select the appropriate NDT methods for the specimen.
CO 3	Calibrate the instrument and evaluate the component for imperfections.
CO 4	Have a basic knowledge of ultrasonic testing which enables them to perform inspection of samples.
CO 5	Have a complete theoretical and practical understanding of the radiographic testing, interpretation and evaluation.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	**3**	3	2									1
CO 2	**3**	3	2									1
CO 3	**3**	3	1									2
CO 4	**3**	3	2									2
CO 5	**3**	3	1									1

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	25	25	25
Understand	25	25	25
Apply	30	30	30
Analyse	10	10	10
Evaluate	10	10	10
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Explain why NDT methods were initially developed
2. Describe the uses of NDT
3. Define the functionality of Destructive method

Course Outcome 2 (CO2)

1. Name the various nondestructive test methods
2. Recognize the NDT method abbreviations
3. Briefly explain each NDT method

Course Outcome 3(CO3):

1. Explain the discontinuities inherent in various manufacturing processes
2. Define the causes, prevention, and repair of those welding discontinuities
3. Explain the discontinuities inherent in various welding processes

Course Outcome 4 (CO4):

1. Explain basic principle of Radiographic examination.
2. Discuss principle of radiographic testing and give its application and limitation

3. Explain the principle, application and disadvantages of Radiographic Testing.

Course Outcome 5 (CO5):

1. Describe the various types of RT equipment

2. Describe the basic principles of gamma and X-ray generation

3. Name the three means of protection to help reduce exposure to radiation

MODEL QUESTION PAPER

SIXTH SEMESTER MECHANICAL ENGINEERING

NON DESTRUCTIVE TESTING - MET 312

Max. Marks : 100 **Duration : 3 Hours**

Part – A

Answer all questions, each question carries 3 marks

1. Define Non-destructive testing?
2. Explain the basic principle of Visual testing?
3. Explain the sequence of operation of Liquid penetrant testing?
4. Explain the basic principle of Liquid penetrant testing?
5. How are the materials classified based on their interaction with a magnetic field?
6. Explain the Hysteresis Loop and Magnetic Properties of a material?
7. Compare X-rays and Gamma rays?
8. What is Snell's Law and it's significance in Ultrasonic Testing?
9. Define the terms (a) Radiation Energy, (b) Intensity
10. What are the physical aspects of E.C.T?

PART -B

Answer one full question from each module.

MODULE – 1

11. a) With the help of suitable examples, differentiate between destructive and nondestructive testing techniques. **(8 Mark)**

b) With the help of a neat diagram, explain computer enhanced visual inspection system. **(6 Mark)**

OR

12. a) Explain visual inspection process. Also explain about the different types of optical aids used in the process. **(8 Mark)**

b) List the applications and Limitations of Visual inspection technique in NDT **(6 Mark)**

MODULE – 2

13. a) How are the penetrants classified based on **(8 Mark)**

a. Physical properties
b. Removal techniques
c. Strength of indication

b) What are the methods used to remove excess penetrants during LPI **(6 Mark)**

OR

14. a) Explain the working principle of liquid penetrant inspection (LPI). With neat sketches explain the various steps involved in performing LPI. **(8 Mark)**

b) Explain different types of developers and how it is being applied **(6 Mark)**

MODULE – 3

15. a) With the help of neat sketches explain about any four types of magnetization techniques used in magnetic particle inspection (MPI). **(8 Mark)**

b) What are the differences between dry and wet continuous MPI? **(6 Mark)**

OR

16. a) Differentiate between direct and indirect method of magnetization. Write the advantages and disadvantages of both methods. **(8 Mark)**

b) What is continuous testing and residual technique of MPI **(6 Mark)**

MODULE – 4

17. a) With the help of neat figures, differentiate between through transmission technique and pulse echo testing techniques used in ultrasonic testing. **(8 mark)**

b) What are the different types of probes used in ultrasonic testing? **(6 mark)**

OR

18. a) What are the different wave forms used in ultrasonic testing? **(8 Mark)**

b) With neat sketches explain the following: **(6 mark)**

i) A-Scan ii) B-Scan iii) C-Scan

MODULE – 5

19. a) With neat sketches explain about the different inspection techniques in radiography testing (RT). **(8 Mark)**

b) Explain about various steps involved in film processing in RT. **(6 mark)**

OR

20. a) Explain the following terms associated with ECT: **(8 Mark)**

i) Lift off effect ii) Edge effect iii) End effect

b) Explain about eddy current testing (ECT) technique in detail. **(6 mark)**

SYLLABUS

Module 1

NDT Versus Mechanical testing-Overview of the Non Destructive Testing Methods for the detection of manufacturing defects as well as material characterisation-Relative merits and limitations-various physical characteristics of materials and their applications in NDT.

Visual Inspection: Fundamentals of Visual Testing – vision, lighting, material attributes, environmental factors, visual perception, direct and indirect methods – mirrors, magnifiers, Boroscopes and fibro scopes– light sources and special lighting–calibration- computer enhanced system

Module 2

Liquid Penetrant Inspection: Principles – types and properties of liquid penetrants – developers – advantages and limitations of various methods - Preparation of test materials – Application of penetrants to parts, removal of excess penetrants, post cleaning – Control and measurement of penetrant process variables –selection of penetrant method – solvent removable, water washable, post emulsifiable – Units and lighting for penetrant testing – calibration- Interpretation and evaluation of test results - dye penetrant process applicable codes and standards.

Module 3

Magnetic Particle Inspection (MPI): Important terminologies related to magnetic properties of material, principle-magnetizing technique, procedure, and equipment, fluorescent magnetic particle testing method, sensitivity-application and limitation-Methods of magnetization, magnetization techniques such as head shot technique, cold shot technique- central conductor testing, and magnetization using products using yokes-direct and indirect method of magnetization - continuous testing of MPI, residual technique of MPI- checking devices in MPI, Interpretation of MPI, indications, advantage and limitation of MPI.

Module 4

Ultrasonic Testing: Basic principles of sound propagation, types of sound waves, Principle of UT-methods of UT, their advantages and limitations-Piezoelectric Material, Various types of transducers/probe-Calibration methods, contact testing and immersion testing, normal beam and straight beam testing, angle beam testing, dual crystal probe, ultrasonic testing techniques resonance testing, through transmission technique, pulse echo testing technique, instruments used UT, accessories such as transducers, types, frequencies, and sizes commonly used. Reference of standard blocks-technique for normal beam inspection-flaw characterization technique, defects in welded products by UT-Thickness determination by ultrasonic method;- Study of A, B and C scan presentations-Time of Flight Diffraction (TOFD).

Module 5

Radiography: X-rays and Gamma rays, Properties of X-rays relevant to NDE - Absorption of rays - scattering. Characteristics of films- graininess, Density, Speed, Contrast. Characteristic curves. Inspection techniques like SWSI, DWSI, DWDI, panoramic exposure, real time radiography, films used in industrial radiography

Eddy Current Testing: Generation of eddy currents – effect of change of impedance on instrumentation – properties of eddy currents – eddy current sensing elements, probes, type of coil arrangement – absolute, differential, lift off, operation, applications, advantages, limitations Field factor and lift of effect, edge effect, end effect, impedance plane diagram in brief, depth of penetration of ECT, relation between frequency and depth of penetration in ECT.

Text Books

1. Baldev Raj, Practical Non – Destructive Testing, Narosa Publishing House, 1997

2. J.Prasad and C. G. K. Nair, Non-Destructive Test and Evaluation of Materials, Tata McGraw-Hill Education, 2nd edition (2011).

3. B.Raj, T. Jayakumar and M. Thavasimuthu, Practical Non Destructive Testing, Alpha Science International Limited, 3 rd edition (2007).

4. T. Rangachari, J. Prasad and B.N.S. Murthy, Treatise on Non-destructive Testing and Evaluation, Navbharath Enterprises, Vol.3, (1983).

5. Ed. Peter.J. Shull, Non-destructive Evaluation: Theory, Techniques, and Applications, Marcel Dekker (2002). 2.

Reference Books

1. C. Hellier, Handbook of Non-Destructive Evaluation, McGraw-Hill Professional, 1st edition (2001).

2. J. Thomas Schmidt, K. Skeie and P. Maclntire, ASNT Non Destructive Testing Handbook: Magnetic Particle Testing, American Society for Non-destructive Testing, American Society for Metals, 2nd edition (1989).

3. Krautkramer, Josef and Hebert Krautkramer, Ultrasonic Testing of Materials, Springer Verlag, 1990

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
MODULE 1		
1.1	NDT Versus Mechanical testing-Overview of the Non Destructive Testing Methods for the detection of manufacturing defects as well as material characterisation	2
1.2	Relative merits and limitations-various physical characteristics of materials and their applications in NDT	1
1.3	Fundamentals of Visual Testing – vision, lighting, material attributes, environmental factors, visual perception, direct and indirect methods	1
1.4	Mirrors, magnifiers, Boroscopes and fibro scopes	1
1.5	light sources and special lighting, calibration- computer enhanced system	2
	MODULE 2	
2.1	**Liquid Penetrant Inspection:** Principles – types and properties of liquid penetrants – developers	1
2.2	Advantages and limitations of various methods - Preparation of test materials	1
2.3	Application of penetrants to parts, removal of excess penetrants, post cleaning	1
2.4	Control and measurement of penetrant process variables –selection of penetrant method	1
2.5	solvent removable, water washable, post emulsifiable – Units and lighting for penetrant testing	1
2.6	calibration- Interpretation and evaluation of test results - dye penetrant process applicable codes and standards	2
MODULE 3		
3.1	**Magnetic Particle Inspection (MPI):** Important terminologies related to magnetic properties of material	1
3.2	Principle-magnetizing technique, procedure, and equipment, fluorescent magnetic particle testing method, Sensitivity	1
3.3	Methods of magnetization, magnetization techniques such as head shot technique, cold shot technique- central conductor testing,	1
3.4	magnetization using products using yokes-direct and indirect method of magnetization - continuous testing of MPI	1
3.5	residual technique of MPI- checking devices in MPI	1
3.6	Indications, advantage and limitation of MPI.	1
MODULE 4		
4.1	Ultrasonic Testing: Basic principles of sound propagation, types of	

	sound waves, Principle of UT-methods of UT	1
4.2	Piezoelectric Material, Various types of transducers/probe Calibration methods, contact testing and immersion testing, normal beam and straight beam testing,	1
4.3	Angle beam testing, dual crystal probe, ultrasonic testing techniques resonance testing, through transmission technique, pulse echo testing technique	1
4.4	Accessories such as transducers, types, frequencies, and sizes commonly used. Reference of standard blocks	1
4.5	Technique for normal beam inspection Thickness determination by ultrasonic method	1
4.6	Study of A, B and C scan presentations, Instruments used UT	1
4.7	Time of Flight Diffraction (TOFD).	1
	MODULE 5	
5.1	**Radiography:** X-rays and Gamma rays, Properties of X-rays relevant to NDE - Absorption of rays - scattering	1
5.2	Characteristics of films- graininess, Density, Speed, Contrast. Characteristic curves. Inspection techniques like SWSI, DWSI, DWDI	1
5.3	Panoramic exposure, real time radiography, films used in industrial radiography	1
5.4	**Eddy Current Testing:** Generation of eddy currents – effect of change of impedance on instrumentation – properties of eddy currents	1
5.5	Eddy current sensing elements, probes, type of coil arrangement – absolute, differential, lift off, operation, applications, advantages, limitations	1
5.6	Field factor and lift of effect, edge effect, end effect, impedance plane diagram in brief, depth of penetration of ECT	1
5.7	Relation between frequency and depth of penetration in ECT.	1

CODE MET322	COURSE NAME COMPUTATIONAL FLUID DYNAMICS	CATEGORY	L	T	P	CREDIT
		PEC	2	1	0	3

Preamble:

This course introduces the students to finite difference methods as a means of solving different types of differential equations that arise in fluid dynamics and heat transfer. Fundamentals of numerical analysis, ordinary differential equations and partial differential equations related to fluid mechanics and heat transfer will be reviewed. Error control and stability considerations are discussed. A class of methods used in computational fluid dynamics for numerically solving the Navier-Stokes equations normally for incompressible flows will be covered in this course.

Prerequisite: MET 203 Mechanics of Fluids

Course Outcomes: After the completion of the course the student will be able to

CO 1	Understanding the governing equations dominating fluid flow and heat transfer and their mathematical and physical nature.
CO 2	Understand finite difference method to fluid flow problems and the level of errors associated with these methods.
CO 3	Understand and apply finite volume method to fluid flow and heat transfer problems.
CO 4	Understand and apply finite volume method to diffusion and convection problems and various interpolation schemes.
CO 5	Understand various methods in numerically solving Navier Stokes equation for incompressible flows.
CO 6	Understand various graphical techniques to present post processed results.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	2										
CO 2	3	2	1									
CO 3	3	3	1									
CO 4	3	3	1									
CO 5	3	2	1									
CO 6	3	2	1									

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	10
Understand	20	20	20
Apply	20	20	70
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1 Derive Navier Stokes equation in conservative form

2 Write a note on elliptical, parabolic and hyperbolic PDEs as applicable to CFD

3 Explain the applications of CFD in various industries.

Course Outcome 2 (CO2)

1 Explain finite difference method in brief. Give the justification for the choice for the finite difference method

2 Write a note on central and upwind difference schemes for one dimensional steady convection-diffusion equation

3 Obtain a 5-point centre-difference scheme for $\frac{\partial\partial^2\varphi}{\partial\partial x^2}$ at grid-point ***i*** using φ_{i-2}, φ_{i-1}, φ_i, φ_{i+1}, φ_{i+2} and find its truncation error.

Course Outcome 3(CO3):

1. Consider a heat conduction problem governed by $\frac{\partial\partial T}{\partial\partial t} = \alpha \frac{\partial\partial^2 T}{\partial\partial x^2}$. Develop a finite difference representation for this equation by the control-volume approach. Do not assume that the grid is uniform.
2. Explain the features of TDMA method
3. Write a note on explicit and implicit approaches and stability criteria.

Course Outcome 4 (CO4):

1. A property φ is transported by means of convection and diffusion through the one-dimensional domain. The governing equation is $[Dw$ □□$(De - Fe)$ □□$(Fe - Fw)]$□P □□Dw□W □□$(De - Fe)$□E; the boundary conditions are φ_0□□1 at x □□0 and φL □□0 at x □□L. Using QUICK scheme for convection and diffusion, calculate the distribution of □□as a function of x for (i) Case1: u □□0.1 m/s, (ii) Case 2: u □□2.5 m/s

2. Explain Crank-Nicolson implicit scheme used for solving the parabolic partial differential equations
3. A property φ is transported by means of convection and diffusion through the one-dimensional domain. The governing equation is $[Dw + (De - Fe) + (Fe - Fw)]\varphi P = Dw\varphi W + (De - Fe)\varphi E$; the boundary conditions are $\varphi_0 = 1$ at $x = 0$ and $\varphi L = 0$ at $x = L$. Using upwind differencing scheme for convection and diffusion, calculate the distribution of φ as a function of x for (i) Case 1: $u = 0.1$ m/s, (ii) Case 2: $u = 2.5$ m/s with the coarse five-point grid

Course Outcome 5 (CO5):

1. Derive the expression for vorticity at the wall in terms of stream function. The expression should contain the interior points only. One could use no-slip velocity boundary condition at the wall in deriving the expression.
2. Write voticity stream function equations
3. Describe the philosophy of Pressure Correction technique. Explain how boundary conditions are specified consistent with the philosophy of Pressure Correction method

Course Outcome 6 (CO6):

1. Explain SIMPLE Algorithm
2. Derive Pressure Correction formula considering two dimensional flows and explain step by step procedure for SIMPLE algorithm
3. Write a note on computer graphics techniques used to present post processed CFD results

Model Question paper

MECHANICAL ENGINEERING

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SIXTH SEMESTER B.TECH DEGREE EXAMINATION

Course Code: MET 322

Course Name: COMPUTATIONAL FLUID DYNAMICS

Max. Marks: 100 Duration: 3 Hours

PART A

ANSWER ALL QUESTIONS, EACH QUESTION CARRIES 3 MARKS)

1. Explain the merits and demerits of numerical approaches over theoretical and experimental approaches.
2. Show that the second-order wave equation is a hyperbolic partial differential equation.
3. Using Taylor series, derive a first order and a second order difference equation for $\frac{\partial\partial u}{\partial\partial y}$.
4. Explain the relaxation techniques used in numerical schemes.
5. Explain Dirichlet, Neumann, and Robins type boundary conditions.
6. Derive the difference equation for steady one-dimensional heat conduction problem.
7. Discuss a situation where upwind differencing scheme is preferred over central differencing scheme.
8. Suggest a numerical difference scheme for which numerical false diffusion is desirable and justify your suggestion.
9. Explain any three graphical methods to present CFD results.
10. Discuss the importance of staggered grid in numerically solving incompressible viscous flow problems. (10 X 3 = 30 Marks)

PART B

Module 1

(ANSWER ONE FULL QUESTION FROM EACH MODULE)

11. Explain the significance of parabolic, hyperbolic and elliptic partial differential equations in a numerical perspective. (14 Marks)

12. Write down the Navier-Stokes equation in vector form by clearly mentioning the solution vector, flux vector and source vector. Convert the Navier-Stokes equations into non-dimensional form. (14 Marks)

Module 2

13. Consider the viscous flow of air over a flat plate. At a given station in the flow direction, the variation of the flow velocity, u, in the direction perpendicular to the plate (the y direction) is given by the expression $u = 21582\left(1 - \left(\frac{-y}{L}\right)\right)$ where L= characteristic length= 0.05 m. The unit of u is m/s. The viscosity coefficient $\mu = 1.81 \times 10^{-5}$ kg/(m.s). Using the equation for u, find the values of u at discrete grid points equally spaced in the y direction with $\Delta y = 0.002m$. With the values obtained at discrete grid points located at y=0, 0.002 m, 0.004 m, and 0.006 m, calculate the shear stress at the wall r_w (a) using a first order difference equation and (b) second order difference equation. Compare these calculated finite difference results with the exact value of tau-w which can be found by making use of the expression for u. (14 Marks)

14. The equation for deflection of a beam is given by $\frac{d^2y}{dx^2} - e^{x^2} = 0$ and deflection at $x = 0$ and $x = 1$ are given by $y(0) = 0$ and $y(1) = 0$. Use the difference equations to find the approximate deflection at $x = 0.25, 0.5,$ and 0.75. (14 Marks)

Module 3

15. Consider the problem of source-free heat conduction in an insulated rod of 0.5 m length whose ends are maintained at constant temperatures of 100°C and 500°C respectively. The one-dimensional problem is governed by $\frac{d}{dx}\left(k\frac{dT}{dx}\right) = 0$. Calculate the steady state temperature distribution in the rod using finite volume method. Thermal conductivity k equals 1000 W/m.K, cross-sectional area A is $10 \times 10^{-3} m^2$. Use cell centered grid points. (14 Marks)

16. Two plastic sheets, each 5 mm thick, are to be bonded together with a thin layer of adhesive that fuses at 140 ^oC. For this purpose, they are pressed between two surfaces at 250 ^oC. Using finite volume method, determine the time for which the two sheets should be pressed together, if the initial temperature of the sheets (and the adhesive) is 30 ^oC. For plastic sheets, thermal conductivity k=0.25 W/m-K, specific heat C=2000J/kg-K and density,ρ= 1300 kg/m^3. (14 Marks)

Module 4

17. A property φ is transported by means of convection and diffusion through the one-dimensional domain $0 \le X \le L$. The governing equation is $\frac{d}{dx}(\rho u\varphi) = \frac{d}{dx}\left(\Gamma\frac{d\varphi}{dx}\right)$ the boundary conditions are $\varphi_0 = 1$ at $x = 0$ and $\varphi_L = 0$ at $x = L$. Using five equally spaced cells and the central differencing scheme for convection and diffusion, calculate the distribution of φ as a function of x for $u = 0.1$m/s. Compare the results with the analytical solution $\frac{\varphi - \varphi_0}{\varphi_L - \varphi_0} = \frac{\exp\left(\frac{\rho u x}{\Gamma}\right) - 1}{\exp\left(\frac{\rho u L}{\Gamma}\right) - 1}$. (14 Marks)

18. Make a comparison of central differencing scheme and upwind differencing scheme. Explain the influence of numerical false diffusion on these two schemes. (14 Marks)

Module 5

19. Derive the stream function- vorticity formulation for the Navier-Stokes equation by clearly stating the assumptions. (14 Marks)

20. Explain the SIMPLE algorithm. Make a discussion of the pressure correction equation and the boundary conditions for the pressure correction equation. (14 Marks)

MODULE : 1 Governing equations of fluid mechanics and heat transfer; fundamental equations – continuity equation, momentum equation and energy equation; non-dimensional form of equations; boundary layer equations for steady incompressible flows. Physical and mathematical classifications of partial differential equations. Comparison of experimental, theoretical and numerical approaches; applications of CFD.
MODULE : 2 Discretization-converting derivatives to their finite difference forms-Taylor's series approach, polynomial fitting approach; forward, backward and central differencing Schemes. Discretization error, truncation error, round off error. Consistency and numerical stability, iterative convergence, condition for convergence, rate of convergence; under and over relaxations, termination of iteration.
MODULE : 3 Finite volume method for Steady one–dimensional conduction problems; handling of boundary conditions; two-dimensional steady state conduction problems; point-by-point and line-by-line method of solution; dealing with Dirichlet, Neumann, and Robins type boundary conditions; tri-diagonal matrix algorithm; transient heat conduction problems - explicit, implicit, Crank-Nicholson and ADI schemes.
MODULE : 4 Finite volume method for diffusion and convection-diffusion problems; steady one-dimensional convection and diffusion; upwind, hybrid, power-law and QUICK schemes; false diffusion.
MODULE : 5 Computation of the flow field using stream function-vorticity formulation. Two dimensional incompressible viscous flow. Staggered grid. Pressure correction methods. Solution algorithm for pressure-velocity coupling in steady flows-SIMPLE algorithm. Boundary conditions for the pressure correction method. Computer graphics techniques to present CFD results.

Text Books

1. S V Patankar, Numerical Heat Transfer and Fluid Flow, McGraw-Hill
2. John D Anderson Jr, Computational Fluid Dynamics, McGraw-Hill Book Company

Reference Books

1. K Muralidhar, T Sundararakjan, Computational Fluid Flow and Heat transfer, Narosa, 2nd Edition, 2011
2. Tapan K Senguptha, Computational Fluid Dynamics, University Press, 2005

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
	Module I	
1	Fundamental equations fluid mechanics and heat transfer	1
2	Continuity equation, momentum equation and energy equation;	2
3	Non-dimensional form of equations	1
4	Boundary layer equations for steady incompressible flows.	1
5	Physical and mathematical classifications of partial differential equations.	1
6	Comparison of experimental, theoretical and numerical approaches; applications of CFD.	1
	Module II	
1	Discretization-converting derivatives to their finite difference forms-Taylor's series approach and polynomial fitting approach	1
2	Forward, backward and central differencing Schemes.	1
3	Discretization error, truncation error, round off error	1
4	Consistency and numerical stability	1
5	Iterative convergence, condition for convergence, rate of convergence	1
6	Under and over relaxations, termination of iteration.	1
	Module III	
1	Finite volume method for steady one–dimensional conduction problems	1
2	handling of boundary conditions;	1
3	two-dimensional steady state conduction problems; point-by-point and line-by-line method of solution;	1
4	dealing with Dirichlet, Neumann, and Robins type boundary conditions;	1
5	tri-diagonal matrix algorithm;	1
6	transient heat conduction problems -explicit, implicit, Crank-Nicholson schemes	2
7	ADI scheme	1
	Module IV	
1	Finite volume method for diffusion and convection-diffusion problems;	1
2	Upwind scheme for steady one-dimensional convection and diffusion	1
3	Hybrid scheme and power-law scheme	2
4	QUICK scheme	1
5	Numerical false diffusion	1
	Module V	
1	Computation of the flow field using stream function-vorticity formulation.	2
2	Two dimensional incompressible viscous flow.	1
3	Staggered grid. Pressure correction methods.	1
4	Solution algorithm for pressure-velocity coupling in steady flows-SIMPLE algorithm.	2
5	Boundary conditions for the pressure correction method.	1
6	Computer graphics techniques to present CFD results.	1

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
MET332	ADVANCED MECHANICS OF SOLIDS	PEC	2	1	0	3

Preamble: This elective course is designed to guide the student to move to the next level of what was included in the third semester course on Strength of Materials (MET 201 MECHANICS OF SOLIDS). Some of the materials which are usually preliminary for a paper like this, have got discussed in that prerequisite, and hence not repeated here. Application of stress and strain analysis in two and three dimensions to solve engineering problems is what is aimed at. The course is supposed to serve necessary background material for future courses on Finite Element Method, and advanced courses on Elasticity.

Prerequisite: MET 201 MECHANICS OF SOLIDS

Course Outcomes: After the completion of the course the student will be able to

CO 1	Formulate the field equations of Elasticity.
CO 2	Model some engineering problems as two-dimensional, for easy solutions involving a Stress Function.
CO 3	Develop solutions for axi-symmetric problems for applications in thick pressure vessels and in rotating circular discs.
CO 4	Extend the basic ideas related to theory of elastic flexure, for skewed loading and for beams which are curved.
CO 5	Apply solution methods for torsion in components with non-circular cross sections and thin walled structures.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	2	1									
CO 2	2	3	1									
CO 3	2	3	1									
CO 4	3	2	1									
CO 5	2	3	1									

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	10
Understand	20	20	20
Apply	20	20	70
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Formulate all Field equations of elasticity.

2. Establishing the compatibility equations.

3. Realizing the differences between the formulation strategies of solutions in solid mechanics.

4. Formal proof for the uniqueness of the intended solutions.

Course Outcome 2 (CO2)

1. Realization that a vast majority of problems reduces to two-dimensional (either plane-stress or plane strain).

2. Formulating the Airy's stress function for two-dimensional problems.

3. Extending the Airy's method to solve practical problems like that encountered in contact analysis.

Course Outcome 3(CO3):

1. Formulation of equation for stresses and deflections in axi-symmetric problems.

2. Extend the axi-symmetric solutions for engineering applications in structures which are pressurised from the inside, as well as outside.

3. Extend the axi-symmetric theory to solve stresses and deformations in spinning discs.

Course Outcome 4 (CO4):

1. Extend the basic elastic flexure formula to cases when the load is skewed.

2. Develop the necessary framework to solve stresses in curved beams.

Course Outcome 5 (CO5):

1. Applying the St. Venant's torsion theory for non-circular cross sections

2. Applying Prandtl's Stress Function to solve Torsion and its applicability in terms of Membrane Analogy.

3. Stress analysis in thin walled closed sections.

Model Question paper

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SIXTH SEMESTER B.TECH DEGREE EXAMINATION

Course Code : MET332 Course Name : ADVANCED MECHANICS OF SOLIDS

Max. Marks : 100 Duration : 3 Hours

PART – A (ANSWER ALL QUESTIONS, EACH QUESTION CARRIES 3 MARKS)

1. Discuss the different types of boundary conditions encountered in the solution of elasticity problems.

2. What are Compatibility equations? Why are they essential in solving elasticity problems?

3. Express stress-strain relations in Matrix format for Plane-Stress and Plane-Strain problems.

4. Elucidate an example for the application of superposition in solving contact stress problems.

5. Derive expressions for circumferential and axial stresses in a thin cylindrical pipe of diameter 'd', thickness 't' and subjected to internal pressure 'P'.

6. Derive expressions for Circumferential Strain and Radial Strain for a two-dimensional thick cylinder (axi-symmetric) problem.

7. Discuss the significance of Shear-Centre in solving Bending of beams.

8. State all relevant assumptions in solving bending stress problems in curved beams using Winkler- Bach theory.

9. Elucidate the difference in approach between St. Venant's theory and Prandtl's theory in the solution of torsion problems.

10. How are torsion problems solved experimentally, making use of Prandtl's membrane analogy?

PART – B (ANSWER ONE FULL QUESTION FROM EACH MODULE)

MODULE – 1

11. (a) For a two-dimensional stress problem described using cylindrical coordinates, derive the equations of equilibrium in terms of (r,θ). (10 Marks)

(b) For the following plane strain distribution, verify whether the compatibility condition is satisfied:

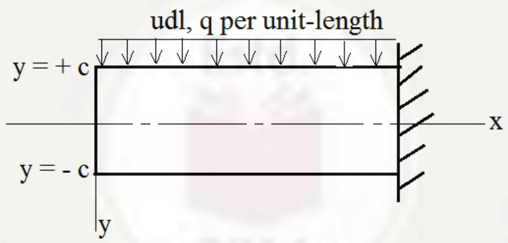
$\varepsilon_{xx} = 3x^2y$, $\varepsilon_{yy} = 4y^2x + 10^{-2}$, $\gamma_{xy} = 2xy + 2x^3$ (4 Marks)

12. (a) Given the fact that the strain energy density is positive-definite, show that the field equations of elasticity yields a Unique solution for a given system of forces and boundary conditions. (8 marks)

(b) Derive the equations of equilibrium in rectangular Cartesian coordinates. (6 Marks)

MODULE – 2

13. Figure shows a cantilever (of depth 2c) loaded by u.d.l. of magnitude 'q'. If the Airy's stress function for this problem is $\varphi = A\,[y^5 - 2c^2y^3 - 10x^2y^3 + 30c^2x^2y - 20c^3x^2]$, (a) show that it is an acceptable stress function for Airy's method and (b) evaluate 'A' for this problem. (14 Marks)



14. If the Airy' stress function (φ)in polar coordinates for solving contact stresses due to line-load on a straight boundary is $\varphi(r, \theta) = -\,(W/L\pi)\, r\, \theta\, \sin\theta$ (where 'W/L' is the normal load per unit length), (a) show that it is an acceptable stress function for Airy's method (b) evaluate stresses for this two-dimensional stress-field (c) Show that the reactions offered by the resulting stress balances the externally applied load.

(14 Marks)

MODULE – 3

15. (a) Assuming plane stress, the stresses in a hollow thick cylinder of radius ‘a’ and external radius ‘b’ subjected to uniform (compressive) pressure of magnitude P_a and P_b inside and outside respectively is of the form

$$\sigma_r = \frac{E}{1-w^2}\left[C_1(1+w) - C_2(1-w)\frac{1}{r^2}\right]$$

$$\sigma_{\theta\theta} = \frac{E}{1-w^2}\left[C_1(1+w) + C_2(1-w)\frac{1}{r^2}\right]$$

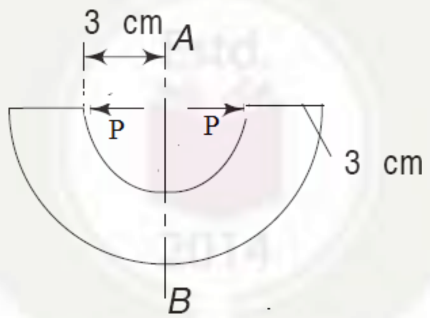
where ‘r’ is the radius at any point. Evaluate the constants C_1 and C_2.

(b) Based on the above, develop expressions for (i) an internally pressurised thick cylinder and (ii) thick cylinder under external pressure. Plot the variation of stresses across thickness for bothcases. (14 Marks)

16. A rotating disc (N=3500 rpm) with a hole has an inner radius of 10 cm and outer radius of 35 cm. If the Poisson’s ratio of the material is 0.3 and density is 8050 kg/m^3, (i) calculate and plot the distribution of radial and circumferential stresses across the radius (ii) Find the maximum values of radial and circumferential stresses . (14 Marks)

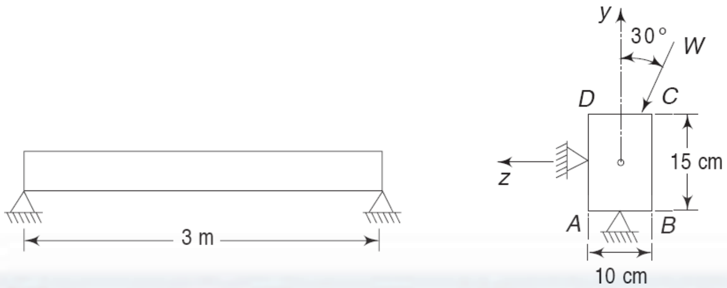
MODULE – 4

17. Find the maximum stress in the section A-B, if the cross-section is a square of sides 3cm x 3cm, for an applied load of P=3000N. Also, plot the variation of stresses across section, indicating the location of centroid and the neutral-axis. (14 Marks)



18. A rectangular beam with a 10 cm ¥ 15 cm section is usedas a simply supported beam of 3 m span. It carries a uniformly distributed load of 1470 N per meter. The load acts in a plane making 30° with the vertical. Calculate the maximum flexural stress at all corners of the cross-section at the mid-span and also locate the neutral axis for the same section.

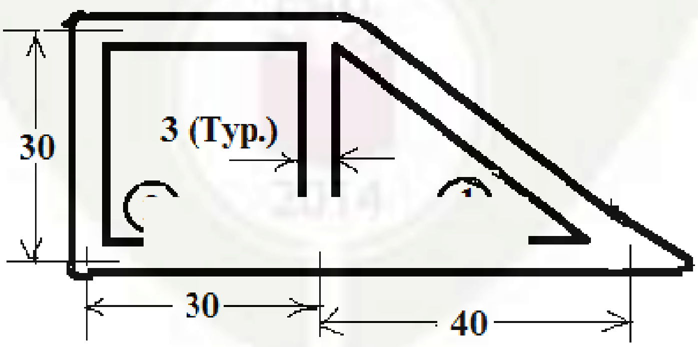
(14 Marks)



MODULE – 5

19. Show that the stress function $m\left(\frac{x^2}{a^2}+\frac{y^2}{b^2}-1\right)$ is a valid Prandtl's stress function for solving torsion problem on an elliptical cross section of major axis 2a and minor axis 2b. Derive expressions for (i) Angle of twist per unit length (ii) Torsional rigidity (iii) Stresses (iv) Max. Stress. (14 Marks)

20. The cross-section of an aerofoil- model in a small wind-tunnel tested for the torque induced due to circulation around it, is idealized as shown in figure. If the shear strength of the material used for the model is 40 MPa and if the shear-modulus, 'G' is 26 GPA, find the limiting-torque for which it can be tested. How much would it deform (angular deflection) under this condition. Use 3mm wall thickness all around. (14 Marks)



All dimensions in mm

Syllabus

Module 1

Field equations of Elasticity: Equations of equilibrium in rectangular and cylindrical polar coordinates – strain-displacement-relations - constitutive equations. Boundary value problems: Different boundary conditions- Examples for Displacement Formulation/ Force Formulation. Compatibility equations - Uniqueness of solution and superposition- St. Venant's principle.

Module 2

Two dimensional problems in elasticity: Stress-strain relations for Plane stress and Plane strain cases. Airy's Stress Functions for solution of stresses: problems in Rectangular as well as in Polar coordinates- contact stresses due to concentrated normal force (line load) on a straight boundary using Airy's stress function, and its extension to solve for stresses due to uniform normal pressure.

Module 3

Axisymmetric problems: Thin cylinders pressurized from inside, and thick cylinders pressurized from inside and outside - Rotating disks.

Module 4

Unsymmetrical bending of straight beams possessing two axes of symmetry-shear center- Winkler Bach theory for Bending of curved beams (with rectangular cross-section).

Module 5

Torsion of non-circular bars: St. Venant's and Prandtl's methods- solutions for elliptical cress-section. Membrane analogy –torsion of thin walled closed sections .

Text Books

1. Nambudiripad K. B. M, "Advanced Mechanics of Solids- A Gentle Introduction", Narosa Publishing House, First Edition, 2018.

2. Srinath L. S., "Advanced Mechanics of Solids", Tata McGraw Hill Publishing Company, Third Edition, 2009.

3. Jose S., " Advanced Mechanics of Materials", Pentagon Educational Services, Second Edition, 2017.

4. Anil lal S., " Advanced Mechanics of Solids", Siva Publications and Distributors, First Edition, 2017.

Reference Books

1. Ragab A. R. and Bayoumi S. E., "Engineering Solid Mechanics, Fundamentals and Applications", CRC Press, First Edition, 2018.

2. Timoshenko S. P., and Goodier J. N., "Theory of Elasticity", McGraw Hill (India), Private Limited, NewDelhi, Third Edition, 2010.

3. Sadd M. H., " Elasticity: Theory, Applications and Numerics", Academic Press, Indian reprint, 2nd edition, 2012.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Module-1: Field Equations**	**7**
1.1	Review of Stress-tensor, strain-displacement relations and strain tensor. Derivation of Equilibrium equations in rectangular and polar coordinates.	2 Hours
1.2	Generalised Hooke's law for linearly elastic, homogeneous isotropic solids	1 Hour
1.3	Boundary conditions in Elasticity problems with examples, Displacement Formulation/ Force Formulation Uniqueness of Solutions, Method of Super position	2 Hours
1.4	Compatibility equations, St. Venants Principle	2 Hours
2	**Module-2: Two-dimensional problems**	**7**
2.1	Stress-strain relations for Plane –stress and plane strain conditions	1 Hour
2.2	Formulation of the Airys stress function in Rectangular and Polar Coordinates	2 Hours
2.3	Illustrative examples for solutions using Airy's stress function	2 Hours
2.4	Contact stresses due to concentrated normal force (line load) on a straight boundary using Airy's stress function, and its extension to solve for stresses due to uniform normal pressure.	2 Hours
3	**Module-3: Axi-symmetric Problems**	**7**
3.1	Stresses in Thin Cylindrical shells and numerical problems.	1 Hour
3.2	Axisymmetric problems: Basic Formulation	1 Hour
3.3	Application to thick shells	1 Hour
3.4	Numerical problems related to thick shells	1 Hour
3.5	Formulation of rotating disks	1 Hour
3.6	Numerical problems related to rotating disks	2 Hours
4	**Module-4: Special Topics in Bending**	**7**
4.1	Unsymmetrical bending of straight beams possessing two axes of	1 Hour

	symmetry.	
4.2	Numerical problems related to Unsymmetrical bending of straight beams	2 Hours
4.3	Shear Centre	1 Hour
4.4	Winkler Bach theory for Bending of curved beams	1 Hour
4.5	Numerical problems related to Unsymmetrical bending of straight beams	2 Hours
5	**Module-5: Torsion of Non-Circular Sections**	**7**
5.1	St. Venant's torsion theory	2 Hours
5.2	Prandtl's torsion theory	1 Hour
5.3	Membrane Analogy	1 Hour
5.4	Torsion of thin walled cross sections	1 Hour
5.5	Numerical problems on torsion of thin walled sections	2 Hours

CODE	COURSENAME	CATEGORY	L-T-P	CREDITS
MET 342	IC ENGINE COMBUSTION AND POLLUTION	PEC	2-1-0	3

Preamble :

This course provides basic concepts on fuel-air mixing, theory of combustion in IC engines. To provide knowledge on emission control technologies of IC engines.

Prerequisite : Thermal Engineering

Course Outcomes :

After completion of the course the student will be able to

CO1	Explain the basic concepts of fuel air mixing
CO2	Understand the combustion process of SI engine
CO3	Understand the combustion process of CI engine
CO4	Explore various alternate fuels in IC engine
CO5	Describe emission control technologies of IC engine

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2										
CO2	3	1										
CO3	3	1										
CO4	3	2				1	1					
CO5	3	1				1	1					

Assessment Pattern

Bloom Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	10
Understand	20	20	20
Apply	20	20	70
Analyse			
Evaluate			
Create			

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Mark distribution:

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End semester pattern:

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions:

Course Outcome 1 (CO1):

1. Explain the different air-fuel ratios required for different operating conditions of a gasoline engine?
2. What are the different air fuel mixtures on which an engine can be operated?
3. Explain the following; 1.Richmixture, 2.Stoichiometric mixture3. Lean mixture.

Course Outcome 2 (CO2):

1. What are the major factors to be considered for the design of SI engine combustion chamber?
2. Define the terms flame development and flame propagation in engines
3. Using the pressure crank angle diagram (P-θ) explain the different stages of desirable combustion in a SI engine .Also explain how abnormal combustion takes place (P-θ) diagram?

Course Outcome 3 (CO3):

1. Brieflyexplain the thermodynamic analysis of CI engine combustion process.Explain clearly assumption made.
2. Explain the various factors that influence spray penetration in CI engine.
3. What is the effect of EGR in emissions from CI engine?

Course Outcome 4 (CO4):

1. Discuss the salient properties of hydrogen as a fuel.
2. What is the modification to be made in CI engine running on biodiesel? Explain in detail about the use of the biodiesel as fuel in CI engine and various merits and demerits of it use?
3. Explainthe fuel characteristics of alcohols,CNG,LPG & hydrogen?

Course Outcome 5 (CO5):

1. List the major pollutants from SI engines. Howcan we measure and control each of them
2. What are the effects of pollutants from CI engines on environment and human beings? How can these are controlled to certain extent.
3. Explain soot and particulate traps.

MODEL QUESTION PAPER

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

VI SEMESTER B.TECH DEGREE EXAMINATION

MET342: IC ENGINE COMBUSTION AND POLLUTION

Maximum: 100 Marks **Duration: 3 hours**

PART A

Answer all questions, each question carries 3 marks

1. What are the different air fuel mixtures on which an engine can be operated?
2. Why a SI enginerequires a rich mixture during idling and at full load?
3. What are factors that influence the flame speed?
4. What are the various factors affecting knock in spark ignition engine?
5. State briefly about air motion in CI engines using diagrams.
6. What is the effect of delay period on Knock in CI engines?
7. List the components present in the measuring chain for pressure measurement in engine research.
8. Write about the different types of alternate fuels available.
9. What are the various pollutants present in combustion products?
10. What are emission norms? Give the major pollutants that are to be controlled?

(10 X 3 = 30 marks)

PART B

Answer one full question from each module

Module 1

11. Briefly explain the different air-fuel ratios required for different operating conditions of a gasoline engine? (14 marks)
12. Discuss the air fuel ratio requirements of SI engine? (14 marks)

Module 2

13. Explain the stages of combustion in SI engines with suitable flame propagation curve? (14 marks)
14. What is meant by abnormal combustion .Explain the phenomena of knock in SI engine? (14 marks)

Module 3

15. Explain with figures various types of combustion chambers used in CI engine.

(14 marks)

16. Explain the phenomenon of spray evaporation and combustion in CI engine

(14 marks)

Module 4

17. Explain the fuel characteristics of biodiesel, CNG,LPG &hydrogen?

(14 marks)

18. Discuss about the HCCI engine.

(14 marks)

Module 5

19. Write short notes on the formation of particulate and smooth emission in IC engines?

(14 marks)

20. Explain in detail about the different methods used for the measurement of exhaust Emission in petrol engine?

(14 marks)

Syllabus

Module 1

Engine design and operating parameters, Thermo chemistry offuel-air mixtures
Properties of working fluids- unburned mixture composition, burned mixture charts, Exhaust gas composition.

Module 2

Ideal models of engine cycles, Availability analysis of engine processes.Combustion in SI engines- Thermodynamic analysis, Flame structureand speed, Cyclic variations in combustion, partial burning and misfire,abnormal combustion

Module 3

Combustion in CI engines- Phenomenological model of CI engine combustion, Analysis of cylinder pressure data, fuel spray behaviour

Module 4

Utilization of alternate fuels in IC engines- biodiesel, hydrogen, LPG,Natural gas- Advantages and disadvantages- HCCI combustion, ASTMspecifications

Module 5

Engine emission and air pollution- Genesis and formation of pollutants, SI engine emission control technology - CI engine emission control technology, fuel quality, emission standards

Text Books:

1. Ganesan, Internal combustion engines, Tata- Mcgraw Hill Publishers, 2002
2. Ramalingam, K.K., Internal Combustion Engines, Scitech Publications (India) Pvt. Ltd., 2004.
3. F Obert, IC Engines and air pollution, Intext educational publishers, 1973
4. Mathur,M.L., and Sharma,R.P., A Course in Internal Combustion Engines, DhanpatRai Publications, 1993.

Reference Books:

1. Heywood JB, IC Engine fundamentals, McGraw hill book Co, 1989
2. W WPulkrabek, Engineering Fundamentals of the IC Engine, 2nd edition, PHI, 2003
3. B. P. Pundir, Engine Emissions: Pollutant formation and advances in control technology, NarosaPublication,2007

Course Contents and Lecture Schedule

No.	Topic	No. of Lectures
1		
1.1	Engine design and operating parameters, Thermo chemistry offuel-air mixtures	4
1.21.2	Properties of working fluids- unburned mixture composition, burned mixture charts, Exhaust gas composition.	3
2	Combustion in SI engines	
2.1	Ideal models of engine cycles, Availability analysis of engine processes.	2
2.2	Thermodynamic analysis, Flame structureand speed, Cyclic variations in combustion, partial burning and misfire,abnormal combustion	5
3	Combustion in CI engines	
3.1	Phenomenological model of CI engine combustion	4
3.2	Analysis of cylinder pressure data, fuel spray behavior	3
4	Utilization of alternate fuels in IC engines	
4.1	Biodiesel, hydrogen, LPG,Natural gas- Advantages and disadvantages	5
4.2	HCCI combustion, ASTMspecifications	2
5	Engine emission and air pollution	
5.1	Genesis and formation of pollutants	1

5.2	SI engine emission control technology	3
5.3	CI engine emission control technology, fuel quality, emission standards	3

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
MET 352	AUTOMOBILE ENGINEERING	PEC	2	1	0	3

Preamble:
The objective of this course is

- To know the anatomy of automobile in general
- To understand the working of different automotive systems and subsystems
- To update the latest developments in automobiles

Prerequisite: EST 120 Basics of Mechanical Engineering

Course Outcomes: After the completion of the course the student will be able to

CO 1	Explain different automotive systems and subsystems .
CO 2	Illustrate the principles of transmission, suspension, steering and braking systems of an automobile.
CO 3	Build a basic knowledge about the technology in electric vehicles.
CO 4	Summarize the concept of aerodynamics in automobiles.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3											3
CO2	3											3
CO3	3											3
CO4	3											3

Assessment Pattern

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination**
	1	**2**	
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Apply	20	20	70
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Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
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Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. What is the need of clutch and gearbox in an automobile?
2. List out the factors affecting the maximum torque transmitting capacity of a friction clutch,
3. Define over drive and list out its advantages.

Course Outcome 2 (CO2)

1. Explain Ackermann steering mechanism with a neat sketch.
2. Explain in detail the working and function of ABS braking system.
3. Explain the function and advantages of Double Wishbone Suspension system.

Course Outcome 3 (CO3):

1. What is the difference between an electric vehicle and a hybrid vehicle?
2. List out the differences in the chassis design of an electric vehicle comparing with the conventional chassis.
3. Explain the basic operation of a fuel cell.

Course Outcome 4 (CO4):

1. What is the significance of aerodynamic lift in vehicles?
2. Explain the concept of ‘Hatch back Drag’.
3. What are the functions of negative lift aerofoil wings.

Model Question Paper

SIXTH SEMESTER MECHANICAL ENGINEERING

MET 352 AUTOMOBILE ENGINEERING

Max. Marks: 100 Duration: 3 Hours

PART A *(30 marks)*

Answer all questions, each carries 3 marks.

1. List the three types of chassis construction.
2. Explain the loads coming on a chassis frame.
3. Differentiate body roll couple and body overturning couple.
4. Explain the features of Double Wish Bone suspension system.
5. Describe any type of a regenerative brake system.
6. Illustrate the desirable properties of brake pad materials.
7. Define the terms under steer and over steer in automobiles.
8. Explain the advantages of power assisted steering system.
9. Explain the functions of negative lift aerofoil wings.
10. List out the advantages of rear end spoiler in a vehicle.

PART B *(70 marks)*

Answer any one question from each module, each carries 14 marks.

Module 1

11.	a)	Explain the working of worm and roller steering gearbox system with the help of a neat sketch.	(7)
	b)	Explain the common troubles encountered in gear boxes and suggest suitable remedies.	(7)
12.		Compare hydraulic, mechanical, electrical and vacuum methods of operating clutches. Describe a hydraulic operated clutch in detail with help of simple	(14)

		diagram.	
Module 2			
13.	a)	Explain the features of McPherson strut suspension system with a neat sketch.	(8)
	b)	Explain the function of an antiroll bar in a four wheeled vehicle.	(6)
14.	a)	Illustrate the working of swing arm rear wheel drive independent suspension.	(8)
	b)	Explain the features of De Dion axle rear wheel suspension.	(6)
Module 3			
15.	a)	Explain how the braking efficiency of a vehicle is evaluated? Also detail the parameters that affect the braking efficiency.	(7)
	b)	Derive an expression for the brakes applied on front and rear wheels.	(7)
16.	a)	Discuss the working and advantages of ABS over conventional systems.	(8)
	b)	Explain the working of a brake caliper with a neat sketch.	(6)
Module 4			
17.	a)	Explain the working and advantages of turbocharger with a neat sketch.	(8)
	b)	Explain how oil control ring helps in piston lubrication.	(6)
18.	a)	Explain the basic principle of a hydrogen fuel cell and its efficiency.	(8)
	b)	Explain the technology of high speed electric trains.	(6)
Module 5			
19.	a)	Differentiate between fast back drag and hatch back drag.	(7)
	b)	Explain the methods to control the aerodynamic lift in vehicles.	(7)
20.	a)	Illustrate the influence of shape of vehicles on drag coefficients.	(7)
	b)	Explain how profile edge chamfering improves drag in vehicles.	(7)

Syllabus

Module 1

Components of an automobile. General classification. Conventional Chassis construction- Types of frames- Frameless constructions. Vehicle dimensions.

Friction clutch: Principle, dry friction clutches- Pull type diaphragm clutch, multiple diaphragm clutch, multi-plate hydraulically operated automatic transmission clutch, semi centrifugal clutch, fully automatic centrifugal clutch, and integral single plate diaphragm clutch. Electromagnetic clutch operation. Clutch friction materials, wet clutch.

Manual transmission- Need of gear box, power to weight ratio, speed operating range-five speed and reverse sliding mesh, constant mesh, and synchromesh gear boxes. Automatic transmission- Epicyclic gear box - torque convertor – Over drives. Automated manual transmission.

Module 2

Suspension: - suspension geometry, terminology- Macpherson strut friction and spring offset - suspension roll centers:-roll centers, roll axis, roll centre height, short swing and long arm suspension, transverse double wishbone, parallel trailing double arm and vertical pill strut suspension, Macpherson strut suspension, semi-trailing arm rear suspension, telescopic suspension. High load beam axle leaf spring, sprung body roll stability. Rear axle beam suspension- body roll stability analysis:- body roll couple, body roll stiffness, body over turning couple.

Rear suspension: - live rigid axle suspension, non drive rear suspension- swing arm rear wheel drive independent suspension. Low pivot split axle coil spring wheel drive independent suspension, trailing and semi trailing arm rear wheel drive independent suspension. Transverse double link arm rear wheel drive independent suspension, De Dion axle rear wheel suspension - Hydrogen suspension, hydro-pneumatic automatic height correction suspension.

Module 3

Brakes: mechanical and hydraulic brakes (review only) – properties of friction lining and pad materials, theory of internal shoe brake, equations –effect of expanding mechanism of shoes on total braking torque, equations. Braking of vehicles:- brakes applied on rear, front and all four wheels, equations –calculation of mean lining pressure and heat generation during braking operation, equations. – braking of vehicle moving on curved path, simple problems.

Anti Lock Braking system (ABS):- hydro-mechanical ABS - hydro-electric ABS - air-electric ABS. Brake servos: - direct acting suspended vacuum assisted brake servo unit operation - hydraulic servo assisted brake systems. Pneumatic operated disc brakes – electronic-pneumatic brakes. Regenerative braking system.

Module 4

Steering:-basic principle of a steering system– Ackermann –over steer and under steer – slip angle, camber, , king pin inclination, caster, toe-in and toe-out .Steering gear box:-worm and roller type steering gear box – Re-circulating ball nut and rocker lever– need of power assisted steering.

Piston for IC engine, piston rings, piston pin, connecting rod, crank shaft, crank pin, cam shaft, valves, fly wheel, fluctuation of energy and size of fly wheel, hub and arms, stress in a fly wheel rim, simple problems. Fuel injection systems: multiport fuel injection (MPFI) and common rail direct injection (CRDI) systems. Super charging in engines, turbo charger, turbo lag.

Electric Vehicle Technology (EVT): EV Architecture, types of batteries, battery parameters, super capacitors. Fuel cells and its efficiency. EV Chassis – requirements, suspension for EVs. Recent Electric vehicles- Electric mobility aids. Future of electric vehicles –Tesla S, Maglev trains, Electric rail road systems.

Module 5

Aerodynamic drag: pressure drag, air resistance, opposing motion of a vehicle, equations, after flow wake, drag coefficients, various body shapes, base drag, vortices, trailing vortex drag, attached transverse vortices. Aerodynamic lift:-lift coefficients, vehicle lift, underbody floor height versus aerodynamic lift and drag, aerofoil lift and drag, front end nose shape.

Car body drag reduction:-profile edge chamfering, bonnet slope and wind screen rake, roof and side panel chamfering, rear side panel taper, under body rear end upward taper, rear end tail extension, under body roughness. Aerodynamic lift control:- under body dams, exposed wheel air flow pattern, partial enclosed wheel air flow pattern, rear end spoiler, negative lift aerofoil wings. After body drag: - square back drag, fast back drag, hatch back drag, notch back drag.

Text Books

1. Heinz Heisler, Vehicle and engine technology, Butterworth-Heinemann, 2nd edition,1998.

2. R.B. Gupta., Auto design , Satya Prakashan Publishers, New Delhi, 2016 .

3. James Larminie and John Lowry, Electric vehicle technology explained, Wiley publications, 2nd edition, 2015.

4. Kirpal Singh, Automobile Engineering Vol.1 & Vol.2, Standard Publishers, 13th edition, 2020.

Reference Books

4. V.A.W. Hillier, Fundamentals of modern vehicle technology, Butterworth-Heinemann, 2nd edition,1998.

5. Tom Denton, Electric and Hybrid Vehicles, Routledge Publishers, 2nd edition, 2020.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Clutch and transmission**	
1.1	Introduction, Chassis construction- Types of frames.	1
1.2	Frameless construction, Vehicle dimensions	1
1.3	Principle of dry friction clutches- Single plate, Multi plate.	1
1.4	Semi centrifugal clutch, fully automatic centrifugal clutch, and	1
1.5	Integral single plate diaphragm clutch. Electromagnetic clutch operation., clutch friction materials, wet clutches	1
1.6	Sliding mesh, constant mesh , synchromesh gear boxes, epicyclic gear boxes	1
1.7	Torque converertor, Over drives, Automated manual transmission	1
2	**Suspension**	
2.1	Suspension: - suspension geometry, terminology. Macpherson strut friction and spring offset.	1
2.2	Suspension roll centers:-roll centers, roll axis, roll centre height, short swing and long arm suspension.	1
2.3	Transverse double wishbone, parallel trailing double arm and vertical pill strut suspension, Macpherson strut suspension, semi-trailing arm rear suspension, telescopic suspension.	1
2.4	High load beam axle leaf spring, sprung body roll stability. Rear axle beam suspension- body roll stability analysis:- body roll couple, body roll stiffness, body over turning couple.	1
2.5	Rear suspension: - live rigid axle suspension, non drive rear suspension-swing arm rear wheel drive independent suspension.	1
2.6	Low pivot split axle coil spring wheel drive independent suspension, trailing and semi trailing arm rear wheel drive independent suspension.	1
2.7	Transverse double link arm rear wheel drive independent suspension, De Dion axle rear wheel suspension.Hydrogen suspension, hydro-pneumatic automatic height correction suspension.	1
3	**Brakes**	
3.1	Types of Brakes, Properties of friction lining and pad materials.Theory	1

	of internal shoe brake, equations	
3.2	Effect of expanding mechanism of shoes on total braking torque, equations.	1
3.3	Braking of vehicles:- brakes applied on rear, front and all four wheels, equations.	1
3.4	Calculation of mean lining pressure and heat generation during braking operation, equations.	1
3.5	Braking of vehicle moving on curved path, simple problems. Hydro-mechanical ABS - hydro-electric ABS	1
3.6	Air-electric ABS. Brake servos: -direct acting suspended vacuum assisted brake servo unit operation - Hydraulic servo assisted brake systems.	1
3.7	Pneumatic operated disc brakes – electronic-pneumatic brakes. Regenerative braking systems.	1
4	**Steering, Engine and EVT**	
4.1	Ackermann steering mechanism, over steer and under steer .	1
4.2	Worm and roller type steering gear box, Re-circulating ball nut and rocker lever, power assisted steering.	1
4.3	IC engines, piston, rings, pin, flywheel, connecting rod.Crank shaft, crank pin, cam shaft, valve mechanism	1
4.4	Fuel injection systems ,Turbochargers, turbo lag.	1
4.5	EV Architecture, types of batteries, battery parameters, super capacitors. Fuel cells and its efficiency.	1
4.6	EV Chassis – requirements, suspension for EVs. Recent Electric vehicles- Electric mobility aids.	1
4.7	Future of electric vehicles –Tesla S, Maglev trains, Electric rail road systems.	1
5	**Aerodynamics in automobiles**	
5.1	Aerodynamic drag: pressure drag, air resistance, opposing motion of a vehicle.	1
5.2	Flow wake, drag coefficients, various body shapes, base drag, vortices, trailing vortex drag, attached transverse vortices.	1
5.3	Aerodynamic lift:-lift coefficients, vehicle lift. Under body floor height versus aerodynamic lift and drag.Aerofoil lift and drag, front end nose	1

	shape.	
5.4	Car body drag reduction:-profile edge chamfering, bonnet slope and wind screen rake.	1
5.5	Roof and side panel chamfering, rear side panel taper, under body rear end upward taper, rear end tail extension, under body roughness.	1
5.6	Aerodynamic lift control:- under body dams, exposed wheel air flow pattern, partial enclosed wheel air flow pattern, rear end spoiler, negative lift aerofoil wings.	1
5.7	After body drag: - square back drag, fast back drag, hatch back drag, notch back drag.	1

CODE MET362	COURSE NAME PRODUCT DESIGN AND DEVELOPMENT	CATEGORY	L	T	P	CREDIT
		PEC	2	1	0	3

Preamble:

- To create confidence in developing new products.
- To acquaint with methods and tools for product design and development.
- To equip with practical knowledge in conceptualization, design and development of new product.

Prerequisite: NIL

Course Outcomes: After the completion of the course the student will be able to

CO 1	Determine the life cycle of a product and product development process
CO 2	Develop knowledge of robust design and conceptual design
CO 3	Introduce the concept of Design for Manufacturing and Assembly in product design.
CO 4	Use value engineering in the development of product
CO 5	Incorporate ergonomics and rapid prototyping in product development.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	**3**	3	2									
CO 2	**3**	3	2									
CO 3	**3**	3	2									
CO 4	**3**	3	2									
CO 5	**3**	3	2									

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	10
Understand	20	20	20
Apply	20	20	70
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance	: 10 marks
Continuous Assessment Test (2 numbers)	: 25 marks
Assignment/Quiz/Course project	: 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. State the features of a good product design.

2. Explain the morphology of design.

3. Describe about the product life cycle.

Course Outcome 2 (CO2)

1. Discuss the brainstorming technique.

2. Discuss about the robust design.

3. Describe the industrial design process.

Course Outcome 3(CO3):

1. Explain DFM Method in design.

2. Explain the importance of ergonomics in product design.

3. Explain the environmental impacts derived from the manufacturing sector.

Course Outcome 4 (CO4):

1. Discuss the advantages of value analysis.

2. Compare Value analysis and value engineering.

3. Discuss some of the quantitative economic analysis tool used in industry.

Course Outcome 5 (CO5):

1. Describe the steps in reverse engineering.

2. Explain the concept of Concurrent Engineering, Rapid prototyping

3. Explain about the patenting system.

MODEL QUESTION PAPER

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
SIXTH SEMESTER B. TECH DEGREE EXAMINATION
Course Code: MET362

Course Name: PRODUCT DESIGN AND DEVELOPMENT
Max. Marks: 100
Duration: 3 Hours

PART – A

(ANSWER ALL QUESTIONS, EACH QUESTION CARRIES 3 MARKS)

1. How the different types of products are classified?
2. What are the various reasons for the failure of a new product?
3. What are three accuracy points in cam and follower synthesis?
4. What meant by the term "lines of maintenance"?
5. Analyze the corporate social responsibility in ethical view point?
6. Differentiate between fixed cost and variable cost?
7. Explain the term anthropometry?
8. What are the rights of a patentee?
9. Differentiate between drafting and modelling software with suitable examples?
10. Explain different steps in a 3d scanning process

PART – B

(ANSWER ONE FULL QUESTION FROM EACH MODULE)

Module 1

11. Explain the various steps involved the morphology of design? (14 marks)

12. Analyze the steps and responsibilities involved in the development of a new product with the help of an example? (14 marks)

Module 2

13. Discuss the various steps in robust design process? (14 marks)

14. Analyze the various activities involved in the industrial design process? (14marks)

Module 3

15. a) Elaborate the role of ergonomic factors in product design? (8 marks)
    b) Analyze the ergonomic factors that need to be considered in the design of a chair? (6 marks)

16. Explain how the design for assembly affects the product design with the help of two examples?

(14 marks)

Module 4

17. Define Value Engineering. Explain the application of the value engineering concept with the help of two case studies? (14 marks)

18. How the cost of a product is determined? Explain with suitable example. (14 marks)

Module 5

19. Analyze the major factors that contribute to the improved product quality by incorporating the concurrent engineering concept? (14 marks)

20. Explain Stereo-lithography and Fused Deposition Modeling with sketch. Compare the advantages and disadvantages of these techniques? (14 marks)

Syllabus

Module 1

Introduction: Classification/ Specifications of Products, Product life cycle, product mix.

Introduction to product design, Modern product development process Design by evolution, Design by innovation, Morphology of design

Ethics in product design, legal factors and social issues.

Module 2

Creativity Techniques: Creative thinking, conceptualization, brain storming, primary design, drawing, simulation, detail design.

Conceptual Design: Generation, selection & embodiment of concept, Product architecture.

Industrial design: process, need.

Robust Design: Taguchi Designs, Design of experiments.

Module 3

Design for Manufacturing and Assembly: Methods of designing for Manufacturing and Assembly.

Design for Maintenance. Design for Environment.

Ergonomics in product design.

Aesthetics in product design. Concepts of size and texture color.

Module 4

Value Engineering / Value Analysis: Definition. Methodology, Case studies.

Product costing.

Economic analysis: Qualitative & Quantitative.

Psychological and Physiological considerations.

Module 5

Concurrent Engineering -Elements of concurrent engineering, Benefits

Rapid prototyping: concepts, processes and advantages.

Reverse engineering: steps in reverse engineering- hardware and software in reverse engineering

Tools for product design – Drafting / Modeling software.

Patents & IP Acts- Overview, Disclosure preparation.

Text Books

1. Karl T Ulrich, Steven D Eppinger, “Product Design & Development.” Tata McGraw Hill, 2003.

Reference Books

1.Baldwin E N & Neibel B W “Designing for Production.” Edwin Homewood Illinois.

2.Bralla J G (Ed.), “Handbook of Product Design for Manufacture, McGraw Hill, NewYork, 1986

3.D. T. Pham, S.S. Dimov, Rapid Manufacturing-The Technologies and Applications of Rapid Prototyping and Rapid Tooling, Springer – Verlag, London, 2001.

4.David G Ullman, “The Mechanical Design Process.” McGraw Hill Inc Singapore 1992

5.Hollins B & Pugh S “Successful Product Design.” Butter worths London, 1990

6.Jones J C “Design Methods.” Seeds of Human Futures. John Willey, 1970

7.Kevin Otto & Kristin Wood Product Design: “Techniques in Reverse Engineering and new Product Development.”, Pearson Education New Delhi, 2000

8.N J M Roozenberg , J Ekels , N F M Roozenberg “ Product Design Fundamentals and Methods .” John Willey & Sons 1995.

9.Andreas Gebhardt, Rapid Prototyping, Carl Hanser – Verlag, Munich, 2003.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Module 1**	**6**
1.1	Introduction: Classification/ Specifications of Products. Product life cycle.	2
1.2	Product mix. Introduction to product design. Modern product development process.	2
1.3	Innovative thinking. Morphology of design. Ethics in product design Ethics in product design	2
2	**Module 2**	**6**
2.1	Creativity Techniques, Conceptual Design: Generation, selection & embodiment of concept.	2
2.2	Product architecture. Industrial design: process, need.	2
2.3	Robust Design: Taguchi Designs & DOE.	2
3	**Module 3**	**7**
3.1	Design for Manufacturing and Assembly: Methods of designing for Manufacturing and Assembly.	3
3.2	Designs for Maintainability. Designs for Environment. Product costing.	2
3.3	Ergonomics in product design. Aesthetics in product design.	2
4	**Module 4**	**7**
4.1	Value Engineering / Value Analysis: Definition. Methodology,	3
4.2	Case studies.	2
4.3	Economic analysis: Qualitative & Quantitative. Product costing.	2
5	**Module 5**	**9**
5.1	Concurrent Engineering, Rapid prototyping: concepts, processes and advantages.	3
5.2	Reverse engineering: steps in reverse engineering- hardware and software in reverse engineering	2
5.3	Tools for product design – Drafting / Modelling software.	2
5.4	Patents & IP Acts. Overview, Disclosure preparation.	2

CODE	ADVANCED METAL JOINING TECHNIQUES	CATEGORY	L	T	P	Credits
MET372		PEC	2	1	0	3

Preamble:

This course provides student to learn fundamental concepts of advanced welding techniques and their applications to an extent to enable the learner to arrive at a firsthand conclusion on selection of a particular technique best suited to resolve a metal joining problem.

Prerequisite: MET204 Manufacturing process.

Course Outcomes: After the completion of the course the student will be able to:

CO 1	Explain the physics, equipment, applications of EBW and LBW.
CO 2	Summarise the physics, equipment, applications of diffusion welding and adhesive bonding processes.
CO 3	Contrast the physics, equipment, applications of explosive welding with friction welding.
CO 4	Outline the physics, equipment, applications of ultrasonic welding and brazing.
CO 5	Illustrate the physics, equipment, applications of plasma arc welding and magnetically impelled arc butt welding.
CO 6	Select an appropriate welding technique to resolve a metal joining problem.

Mapping of course outcomes with program outcomes:

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	-	-	-	-	-	-	-	-	-	-	2
CO 2	2	-	-	-	-	-	-	-	-	-	-	2
CO 3	2	-	-	2	-	-	-	-	-	-	-	3
CO 4	3	-	2	-	-	-	-	-	-	-	-	2
CO 5	2	-	-	-	1	-	-	-	-	-	-	2
CO 6	3	-	-	-	2	-	-	-	-	-	-	1

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination (marks)
	1 (marks)	2 (marks)	
Remember	20	20	40
Understand	20	20	40
Apply	10	10	20
Analyse	-	-	-
Evaluate	-	-	-
Create	-	-	-

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions.

Course Outcome 1 (CO1):

1. Explain principle of operation of Electron Beam Welding.
2. Illustrate a typical EBW gun.
3. List 2 applications of laser beam welding. Identify the inherent process capability of LBM which makes it suitable for above listed applications.

Course Outcome 2 (CO2):

1. With the help of suitable diagrams, describe various stages in diffusion welding process.
2. Describe various diffusion welding methods.
3. Explain the physics of adhesive bonding.

Course Outcome 3 (CO3):

1. With the help of suitable diagram, describe parallel stand-off and angular stand-off.
2. Compare the mechanism of metal joining in explosive welding with that of friction welding. Give one application for each.
3. Show the effect of rotational speed on duration of friction welding.

Course Outcome 4 (CO4):

1. Describe principle of operation of ultrasonic welding.
2. List all design considerations for a brazed joint.

3. Make a note on hand torch brazing.

Course Outcome 5 (CO5):

1. Differentiate transferred and non-transferred plasma arc processes.
2. Sketch and explain a plasma arc welding system.
3. Describe the steps involved in MIAB with appropriate diagrams.

Course Outcome 6 (CO6):

1. Select a welding process which is considered relatively best for underwater welding. Correlate relevant process capability of the selected technique to support your selection.
2. Select a welding process that is considered best for welding stainless steel. Correlate relevant process capability of the selected technique to support your selection.
3. Suggest a best welding technique to join materials having thin sections. Explain why.

Model Question Paper
SIXTH SEMESTER MECHANICAL ENGINEERING

MET372 ADVANCED METAL JOINING TECHNIQUES

Max. Marks: 100 Duration: 3 hours

Part−A
Answer all questions. Each question carries 3 marks.

1. Draw typical joint designs for electron beam welding.
2. How do you define “f number” for a laser beam?
3. What is vacuum fusion bonding?
4. Write a short note on crack extension test performed on adhesive bonds.
5. What is Impact velocity? How critical is it in creating an explosive weld?
6. Sketch and mark a simple friction welding setup.
7. What is principle of operation of ultrasonic welding?
8. List down essential properties of brazing filler metals.
9. What is “keyholing” in plasma arc welding?
10. What are the advantages of magnetically impelled arc butt welding?

Part−B

Answer one full question from each module.

Module I

11. (a) Draw and explain an EBW equipment. (7 marks)
(b) Discuss all joint configurations commonly used for LBW. (7 marks)

12. (a) Discuss process characteristics of EBW. (7 marks)

(b) Discuss Carbon Dioxide lasers used for welding. (7 marks)

Module II

13. Explain the theory of diffusion welding process. (14 marks)

14. Classify adhesives used for adhesive bonding and explain their characteristics. (14 marks)

Module III

15. With the help of a neat diagram describe different stages in explosion welding. (14 marks)

16. Draw and explain various joint designs employed in friction welding. (14 marks)

Module IV

17. State and explain all variables in ultrasonic welding. (14 marks)

18. Write short notes on (i) torch brazing (ii) furnace brazing (iii) vacuum brazing

(14 marks)

Module V

19. Explain the principle of operation of MIAB welding and steps involved in it with the help of suitable diagrams. (14 marks)

20. Describe the components of a Plasma Arc Welding system and list all applications of PAW. (14 marks)

Syllabus

Module 1

Radiant energy welding: Electron Beam Welding (EBW) - principle and theory- equipment and systems- process characteristics and variables- weld joint design- applications- EBW process variants. Laser Beam Welding-principle and theory-operation-types of lasers-process variables and characteristics-applications.

Module 2

Diffusion welding-principle and theory-methods- welding parameters-advantages and limitations-applications. Cold pressure welding-process, equipment and set-up-applications. Adhesive Bonding-principle and theory-types of adhesives-joint design-bonding methods- applications.

Module 3

Explosive welding-principle and theory-process variables-equipment-joint design-advantages and limitations-applications. Friction welding-principle and theory-process variables-advantages and limitations-applications. Friction stir welding- metal flow phenomena-tools-process variables – applications.

Module 4

Ultrasonic welding-principle and theory-process variables and equipment-types of ultrasonic welds-advantages and limitations-applications. Brazing- principle- brazing processes-torch brazing- furnace brazing- vacuum brazing-induction brazing-advantages and limitations-applications.

Module 5

Plasma arc welding –principle and theory- transferred arc and non-transferred arc techniques-equipment-advantages and limitations-applications. Magnetically impelled arc butt (MIAB) welding-principle of operation-applications. Under water welding-wet and dry under water welding- set-up for underwater welding systems.

Text Books

1. Parmar R.S., Welding Processes and Technology, Khanna Publishers, Delhi, 1998.

Reference Books

1. ASM Metals Handbook "Welding and Brazing", Vol.6, ASM, Ohio, 1988
2. Parmar R.S., "Welding Engineering and Technology" Khanna Publishers, Delhi, 1997
3. Rossi, B.E., Welding Engineering, Mc Graw-Hill, 1954
4. Schwartz M.M., "Metal Joining Manual", McGraw-Hill Inc., 1979
5. Udin et al., Welding for Engineers, John Wiley & Sons, New York, 1967

6. Welding Engineers Handbook – ASHE Vol. I, II, III, IV

Course Contents and Lecture Schedule

No.	Topic	No. of Lectures	COs
1.1	Radiant energy welding: Principle of Electron Beam Welding and theory.	1	CO1
1.2	Types of EBW welding guns.	1	CO1
1.3	EBW equipment and systems.	1	CO1
1.4	Process variables –effect of beam current on weld penetration-effect of	1	CO1

	welding speed on weld penetration.		
1.5	Process variants of EBW-medium vacuum EBW and non-vacuum EBW.	1	CO1
1.6	Typical weld joint design and preparation for EBW.	1	CO1
1.7	Weldable materials using EBW and applications of EBW.	1	CO1CO6
1.8	Principle of Laser Beam Welding, mechanism and operation- types of laser systems- process variables and characteristics.	1	CO1
1.9	Weld joint design – weldable materials and applications of laser beam welding.	1	CO1 CO6
2.1	Diffusion welding- principle and theory.	1	CO2
2.2	Diffusion welding methods- Gas-pressure bonding, Vacuum fusion bonding, Eutectic fusion bonding.	1	CO2
2.3	Diffusion welding parameters.	1	CO2
2.4	Weldable materials using diffusion welding- advantages, limitations and applications.	1	CO2 CO6
2.5	Cold pressure welding equipment and set-up-applications.	1	CO2
2.6	Adhesive bonding- principle and theory- classification of adhesives and types of adhesive materials.	1	CO2
2.7	Joint design and bonding methods – applications.	1	CO2 CO6
3.1	Explosive welding- principle and theory- process variables.	1	CO3
3.2	Set-up for explosion welding- Joint design- advantages and limitations- applications.	1	CO3
3.3	Friction welding- principle and theory- process variables.	2	CO3
3.4	Effect of rotational speed on duration of welding- process characteristics.	1	CO3
3.5	Advantages and limitations-applications. Variants of friction welding- friction stir welding-metal flow phenomena.	2	CO3 CO6
4.1	Ultrasonic welding- principle and theory.	1	CO4
4.2	Ultrasonic process variables and equipment-types of ultrasonic welds.	1	CO4
4.3	Advantages and disadvantages of ultrasonic welding- applications.	1	CO4 CO6
4.4	Brazing-principle-brazing processes- torch brazing- furnace brazing- vacuum brazing-induction brazing-advantages and limitations- applications.	2	CO4
5.1	Plasma Arc welding –principle and theory- transferred arc and non-transferred arc processes.	1	CO5
5.2	Plasma arc welding system.	1	CO5
5.3	Advantages, limitations and applications.	1	CO5 CO6
5.4	Magnetically Impelled Arc Butt (MIAB) welding- principle of operation-applications.	2	CO5 CO6
5.5	Under water welding techniques – wet and dry welding- general arrangement for underwater welding systems.	2	CO5

SEMESTER VI

MINOR

CODE MET382	Course Name MACHINE DESIGN	CATEGORY	L	T	P	CREDIT
		VAC	3	1	0	4

Preamble: This course mainly covers elementary topics of strength of materials such as stresses, strains, stress concentration, etc. Failure theories to predict the failure of machine elements subjected to static and fatigue loading are also covered. Design of bolts, riveted joints, welded joints, springs and shafts are also incorporated in this syllabus.

Prerequisite: EST100 Engineering Mechanics

Course Outcomes: After the completion of the course the student will be able to:

CO 1	To calculate the different types of stresses in a structural member.
CO 2	To apply failure theories and predict the failure of components.
CO 3	To design bolts subjected to fatigue loads.
CO 4	To design riveted and welded joints.
CO 5	To design close coiled helical compression springs and shafts subjected to static and fatigue loads.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3	2									
CO 2	3	3	2									
CO 3	3	3	2									
CO 4	3	3	2									
CO 5	3	3	2									

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	10
Understand	20	20	20
Apply	20	20	70
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance	: 10 marks
Continuous Assessment Test (2 numbers)	: 25 marks
Assignment/Quiz/Course project	: 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Define stress concentration factor and factor of safety.
2. Calculate the principal stresses in a structural member subjected to loads in two directions.
3. Draw stress strain diagram and explain its significance in the design of machine elements.
4. Calculate the equivalent stress due to combined axial, bending and torsional loads.

Course Outcome 2 (CO2)

1. Explain the steps in the design process.
2. Distinguish between codes and standards.
3. Describe with neat sketches the different types of fits.
4. What are the different failure theories? What is the significance in design?

Course Outcome 3 (CO3)

1. Define endurance limit. What are the factors affecting it?
2. Explain Soderberg's and Goodman's criteria.
3. Derive an expression for the impact stress in terms of static stress.
4. What is meant by preloading or initial tension in a bolt?
5. Design a bolted joint subjected to eccentric loading.

Course Outcome 4 (CO4):

1. What are the advantages of riveted joint over welded joint?
2. Describe the different modes of failure of a riveted joint.
3. Find the various efficiencies of a riveted joint.

4. Describe the different AWS welding symbols.
5. Design a welded joint subjected to axial loading, twisting moment and bending moment.

Course Outcome 5 (CO5):

1. Design a close coiled helical compression spring subjected to axial loading.
2. Explain surge in spring.
3. What are the different types of end constructions for a close coiled helical compression spring? How do they affect the performance of the spring?
4. What is critical speed of a shaft?
5. Why hollow shafts are preferred in certain applications compared to solid shafts?

MODEL QUESTION PAPER

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

VI SEMESTER BTECH DEGREE EXAMINATION

MET382 : MACHINE DESIGN

Maximum: 100 Marks　　　　Duration:3 hours

PART A

Answer all questions, each question carries 3 marks

1. Define stress concentration and factor of safety.
2. Distinguish between normal stress and principal stress.
3. What are standards and codes?
4. Explain Haigh's and Rankine's theories of failures.
5. Why preloading of bolts is required?
6. Define endurance limit. What is its significance in design of machine elements?
7. Describe the different modes of failure of a riveted joint.
8. Explain with a neat sketch the AWS welding symbols
9. Derive an expression for the stress in a closed coiled helical compression spring.
10. What is meant by the critical speed of a shaft?

PART B

Answer one full question from each module

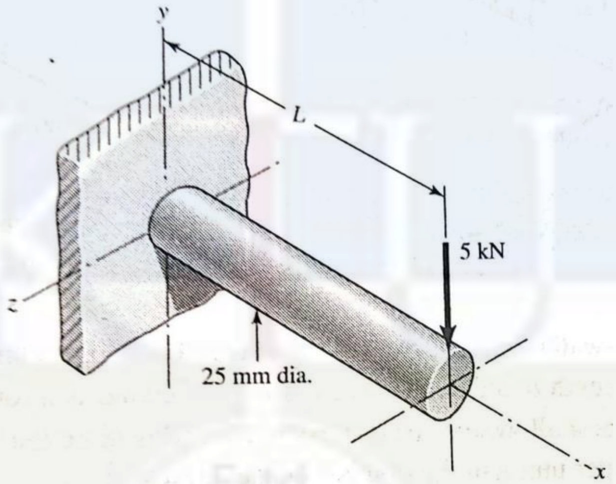
MODULE 1

11. a) An element in plane stress is subjected to stresses σ_{xx} = 85 MPa, σ_{yy} = -30 MPa and τ_{xy} = -32 MPa. Determine the principal stresses and the maximum shear stress (9 marks)

b) Draw the shear stress, bending stress, axial stress and torsional shear stress in a shaft of circular cross-section. (5 marks)

12. a) Draw the stress-strain diagram for mild steel and show all the significant regions. (5 marks)

b) Find the maximum stress in the cantilever beam shown below. The material is aluminium. The rod length L = 15 cm. The permissible tensile and shear stresses are 70 N/mm^2 and 50 N/mm^2 respectively. (10 marks)



MODULE 2

13. a) Explain allowances and tolerances. (5 marks)

b) A mild steel shaft having yield stress σ_{yp}= 2**00** MPa is subjected to the following stresses. $\sigma_x = 120$ MPa, $\sigma_y = -60$ MPa , $\tau_{xy} = 36$ MPa. Find the factor of safety using

a. Rankine's theory
b. Guest's theory (10 marks)

14. a) With neat sketches explain clearance fit, interference fit and transition fit. (6 marks)

b) What are the steps in the design process. (6 marks)

c) Explain preferred sizes. (2 marks)

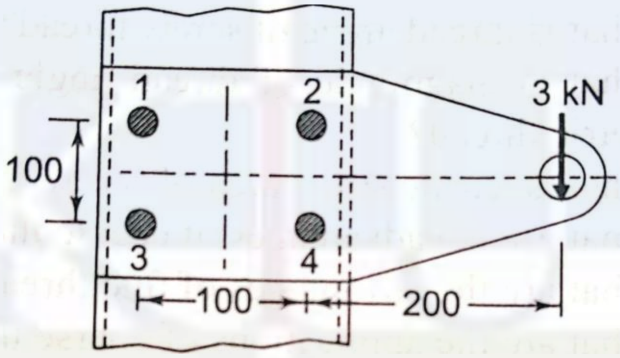
MODULE 3

15. a) A round prismatic steel bar (E = 210 GPa) of length 2 m and diameter 15 mm hangs vertically from a support at its upper end. A sliding collar of mass 20 kg drops from a height of 150 mm onto a flange fixed at the lower end of the bar without rebounding. Calculate the maximum elongation of the bar due to impact. Also, determine the maximum tensile stress in the bar and the corresponding impact factor (10 marks)

b) Explain the Gerber criterion used in the design for fatigue loading. (4 marks)

16. a) With a neat sketch explain the nominal diameter, root diameter and pitch diameter and pitch of a screw thread. (3 marks)

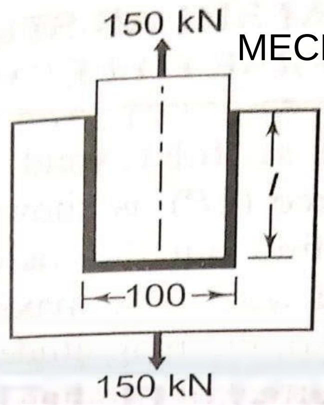
b) Find the diameter of the bolt for a bracket loaded as shown below. The allowable shear stress for bolt material is 60 MPa. (11 marks)



MODULE 4

17. a) What are the advantages of welded joint over riveted joint? (9 marks)

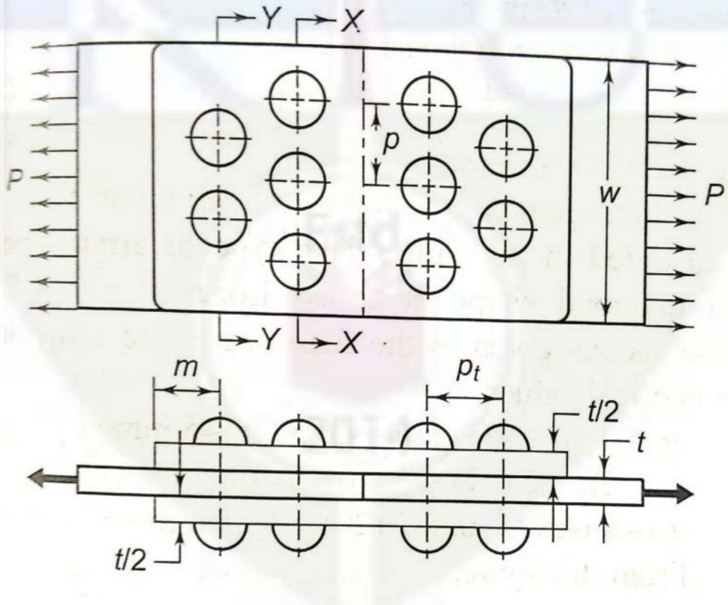
b) Two plates are joined together by means of a single transverse and double parallel fillet welds are shown in figure. The size of the fillet weld is 5 mm and allowable shear load per mm of weld is 330 N. Find the length of each parallel fillet weld. (10 marks)



18. a) Draw a zig-zag-double riveted double covered (equal) butt joint and mark all the details. (4 marks)

b) Two flat plates of width w = 200 mm, subjected to a tensile force P = 250 kN are connected together by means of a double-strap butt joint as shown below. The rivets and the plates are made of the same steel and the permissible stresses in tension, compression and shear are 70, 100 and 60 N/mm^2 respectively. Calculate the i) diameter of the rivets, ii) thickness of the plates and iv) the efficiency of the joint.

(10 marks)



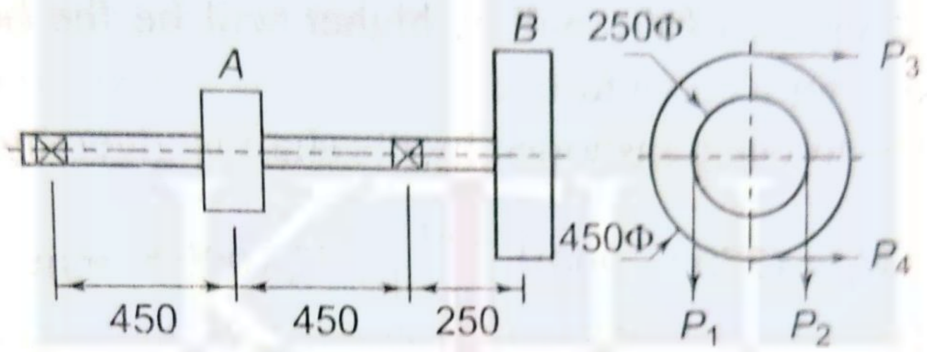
MODULE 5

19. a) Explain surge in springs. (4 marks)

b) It is required to design a helical compression spring subjected to a maximum force of 1250 N. The deflection of the spring corresponding to the maximum force should be approximately 30 mm. The spring index can be taken as 6. The ultimate tensile

strength and modulus of rigidity of the spring material are 1090 and 81370 N/mm^2 respectively. The permissible shear stress for the spring wire should be taken as 50% of the ultimate tensile strength. Design the spring and calculate: i) wire diameter, ii) mean coil diameter, iii) number of active coils, iv) total number of coils, v) free length of the spring and pitch of the coil. (10 marks)

20. a) A line shaft supporting two pulleys A and B is shown in figure. Power is supplied to the shaft by means of a vertical belt on the pulley A, which is then transmitted to the pulley Bcarrying a horizontal belt. The ratio of belt tensions on tight and loose sides is 3:1. The limiting value of tension in the belt is 2.7 kN. The permissible shear stress is 86 N/mm^2. Pulleys are keyed to the shaft. Determine the diameter of the shaft according to the ASME code, if K_b = 1.5 and K_t = 1.0. (10 marks)



b) Two shafts ; one solid and the other hollow, have the same weight and transmit the same torque. Calculate the ratio of the maximum shear stress induced in the solid shat to that in the hollow shaft. The inner diameter of the hollow shaft is 50% of the outer diameter. (5 marks)

Syllabus

Module 1

Tension, compression, shear: Introduction, Internal force, stress, strain, elasticity, stress-strain diagram, working stress, stress concentration, factor of safety, bending and torsional stresses, eccentric loading, stresses due to combined axial, bending and torsional loads, principal stresses

Module 2

Machine design, steps in the design process, standards and codes, preferred sizes, tolerances, allowances, fits, selection of materials

Theories of elastic failures- Guest's theory, Rankine's theory, St. Venant's theory, Haigh's theory, and Von Mises and Hencky Theory.

Module 3

Shock and impact loads, fatigue loading, endurance limit stress, factors affecting endurance limit, design for fatigue loading, Soderberg and Good man criteria.

Threaded joints, types of threads, stresses in screw threads, bolted joints, initial tension, design of bolts for static and fatigue loading, power screws

Module 4

Design of riveted joints- material for rivets, modes of failure, efficiency of joint, design of boiler and tank joints, structural joints

Design of welded joints- AWS welding symbols, stresses in fillet and butt welds, butt joint in tension, fillet weld in tension, fillet joint under torsion, fillet wed under bending, eccentrically loaded welds.

Module 5

Springs- classification, spring materials, stresses and deflection of helical springs, axial loading, , static and fatigue loading, surging, critical frequency, concentric springs, end construction.

Shafting- material, design considerations, causes of failure in shafts, design based on strength, rigidity, critical speed, design for static and fatigue loads, repeated loading, reversed bending

Text Books

1. Bhandari V B, Design of Machine Elements, Tata McGraw-Hill Education, 2010.
2. James M Gere, Mechanics of Materials, Thomson, 2007

.

Reference Books

1. S P Timoshenko and D H Young, Elements of Strength of Materials, East West Pvt Ltd.,2011

3. Robert L Norton, Design of Machinery, Tata Mc Graw-Hill, 2005

4. P C Sharma and D K Aggarwal, Machine Design, S K Kataria & Sons, 2007.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures (Hrs.)
1		
1.1	Tension, compression, shear-Introduction, internal force, stress, strain, elasticity	3
1.2	Stress-strain diagram, working stress, stress concentration, factor of safety	2
1.3	Bending and torsional stresses, eccentric loading, stresses due to combined axial, bending and torsional loads, principal stresses	3
2		
2.1	Machine design, steps in the design process, standards and codes	3
2.2	Preferred sizes, tolerances, allowances, fits, selection of materials	2
2.3	Theories of elastic failures- Guest's theory, Rankine's theory, St. Venant's theory, Haigh's theory, and Von Mises and Hencky Theory.	3
3		
3.1	Shock and impact loads, fatigue loading, endurance limit stress, factors affecting endurance limit	2
3.2	Design for fatigue loading, Soderberg and Goodman's criteria.	2
3.3	Threaded joints, types of threads, stresses in screw threads, bolted joints, initial tension	2
3.4	Design of bolts for static and fatigue loading, eccentric loading, power screws	2
4		
4.1	Design of riveted joints- material for rivets, modes of failure, rivet and butt joints, efficiency of joint, design of structural joints	3
4.2	Design of welded joints- AWS welding symbols, stresses in fillet and butt welds, Butt joint in tension, fillet weld in tension,	3
4.3	Fillet joint under torsion, fillet wed under bending, eccentrically loaded welds.	3
5		
5.1	Springs- classification, spring materials, stresses and deflection of	3

	helical springs, axial loading	
5.2	Static and fatigue loading, surging, critical frequency, concentric springs, end construction	3
5.3	Shafting- material, design considerations, causes of failure in shafts, hollow and solid shafts, design based on strength, rigidity,	3
5.4	Critical speed, design for static and fatigue loads, repeated loading, reversed bending	3

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
MET 384	HEAT TRANSFER	VAC	3	1	0	4

Preamble:

The objectives of the course are:

- To introduce the heat transfer by conduction, convection and radiation modes.
- To provide useful information for solving the heat transfer problems across the plane and cylindrical sections
- To give enough ideas to solve the heat transfer problems involving convection heat transfer
- To determine the performance of heat exchangers
- Present and solve the various types of radiation heat transfer problems

Prerequisite: MET203 Mechanics of fluid

Course Outcomes: After the completion of the course the student will be able to

CO 1	To understand the basics of heat transfer.
CO 2	To estimate heat transfer through plane wall, cylindrical surface and fins for various conditions.
CO 3	To solve problems involving heat convection.
CO 4	To solve the problems of heat exchangers and to determine its performance.
CO 5	To estimate radiation heat transfer between two bodies.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3											1
CO 2	2	3	2								1	1
CO 3	2	2	2								1	1
CO 4	2	3	2								1	1

Assessment Pattern

Bloom's Category	Continuous Assessment			End Semester Examination
	Assignment (%)	Test 1 (%)	Test 2 (%)	
Remember	30	20	20	10
Understand	30	40	40	20
Apply	40	40	40	70
Analyse				
Evaluate				
Create				

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Explain Fourier's law of heat conduction?
2. Derive the equation of general heat conduction equation in Cartesian coordinates?

Course Outcome 2 (CO2)

1. The interior temperature of a refrigerator is maintained at 7°C. The walls are constructed with two mild steel sheets 3 mm thick with 5 cm of glass wool insulation between them. The heat transfer coefficients on inner and outer surface of refrigerator are 10 W/m2°C and 12.5 W/m2 °C respectively. Find the rate of heat leaked the refrigerator in watts when it is kept in a kitchen room. Also find inter wall temperatures. The temperature in kitchen room is 28°C.Take K (mild steel) =40 W/m-°C K (glass wool) = 0.04 W/m-°C3. Demonstrate the operation of stack and stack pointer through push and pop Instructions.

2. Derive an equation for one dimensional heat conduction through a plane wall and represent it in a form of electrical analogy?

Course Outcome 3(CO3):

1. Explain Newton's law of convective heat transfer?

2. Explain hydrodynamic boundary layer with the help of a neat diagram.

3. Define Reynolds Number, Prandtl Number and Nusselt Number.

Course Outcome 4 (CO4):

1. What is LMTD? What is the need of determine the LMTD?

2. In a double pipe heat exchanger hot water flows at a rate of 14 kg/s and gets cooled from 370K to 340K. At the same time 14 kg/s of cooling water at 303K enters the heat exchanger. The flow conditions are such that overall heat transfer coefficient remains constant at 2270

W/m2 K. Determine the effectiveness and the heat transfer area required, assuming two streams are in parallel flow. Assume the specific heat for the both the streams = 4.2 kJ/kg K.

Course Outcome 5 (CO5):

1. Explains Stephan Boltzmann law of heat radiation?
2. Explain Wien's displacement law?

MODEL QUESTION PAPER

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SIXTH SEMESTER MECHANICAL ENGINEERING

Heat Transfer-MET384

Maximum: 100 Marks **Duration: 3 hours**

PART A

Answer all questions. Each question carries 3 marks

1. Explain Fourier's law of heat conduction?
2. What are the factors affecting thermal conductivity of solids, liquids and gases?
3. Write the equation for one dimensional heat conduction through a plane wall and represent it in a form of electrical analogy?
4. What is critical thickness of insulation and what is its importance?
5. Define Reynolds Number, Prandtl Number and Nusselt Number?
6. What is the difference between free and forced convection?
7. What is meant by NTU in heat exchangers? When it is used?
8. What is effectiveness of a heat exchanger?
9. Explains Stephan Boltzmann law of heat radiation?
10. Explain Wien's displacement law?

(10 X 3 = 30 Marks)

PART B

Answer one full question from each module

MODULE 1

11. a) Derive general conduction equation in Cartesian coordinate? (10 marks)

b)reduce the equation for steady one dimensional conduction heat transfer for homogeneous isotropic material without heat generation. (4marks)

12. a) Explain three different modes of heat transfer? (10 marks)

b) Write down the general conduction equation in cylindrical coordinate and explain the terms?

(4 marks)

MODULE II

13. a) The interior temperature of a refrigerator is maintained at 7°C. The walls are constructed with two mild steel sheets 3 mm thick with 5 cm of glass wool insulation between them. The heat transfer coefficients on inner and outer surface of refrigerator are 10 W/m2°C and 12.5 W/m2 °C respectively. Find the rate of heat leaked the refrigerator in watts when it is kept in a kitchen room. Also find inter wall temperatures. The temperature in kitchen room is 28°C.Take K (mild steel) =40 W/m-°C K (glass wool) = 0.04 W/m-°C. (10 marks)

b) Write an expression for one dimensional heat transfer along radial direction, through a hollow cylindrical surface of radius R1 and R2 , thermal conductivity K and length L. express it as an analogy of electric flow (4 marks)

14 a) Derive an expression for heat flow through "rectangular fin" of infinite length ? (12 marks)

b) What is the propose of a fins? (2 marks)

MODULE III

15 a) Air at 20°C at atmospheric pressure flows over a flat plate at a velocity of 3 m/s. If the plate is 1 m wide and at 80°C, calculate the following at x = 300 mm. Determine Hydrodynamic boundary layer thickness, Thermal boundary layer thickness, Local friction coefficient , Average heat transfer coefficient , Heat transfer rate (10 marks)

b) What is the difference between laminar and turbulent flow? (4 marks)

16 a) Air at pressure of 1 atm and temperature 60°C flows over a flat plate which maintains a surface temperature of 100°C. The plate has a length of 0.2m (in the flow direction) and width of 0.1m. The Reynolds number based on the plate length is 40000. What is the rate of heat transfer from plate to air? If the free stream velocity of air is doubled and the pressure is increased to 2.5 atm, what is the rate of heat transfer? (12 marks)

b) What is the importance of Reynolds number? (2 marks)

MODULE IV

17. a) Derive an expression for LMTD of "parallel flow" heat exchanger (10 marks)

b) What is fouling and scaling of heat exchangers? How to accommodate this factor in calculation

(4 marks)

18. a) A chemical having specific heat of 3.3 KJ/kg K, flowing at the rate of 20000 kg/h enters a parallel flow heat exchanger at 120° C. The flow rate of cooling water is 50000 kg/h with an inlet temperature of 20°C. The heat transfer area is 10 m2 and the overall heat transfer coefficient is 1050 W/m^2 K. Take specific heat of water as 4.186 KJ/kg K Find: (i) The effectiveness of the heat exchanger. (ii) The outlet temperature of water and chemical.

(12 marks)

b) Explain matrix type of heat exchangers? (2 marks)

MODULE V

19 a) Calculate the heat exchange by radiation between the surfaces of two long cylinders having radii 120 mm and 60 mm respectively. The axes of the cylinders are parallel to each other. The inner cylinder is maintained at a temperature of 130°C and emissivity of 0.6. Outer cylinder is maintained at a temperature of 30°C and emissivity of 0.5. (10 marks)

b) Explains Stephan Boltzmann law of heat radiation? (4 marks)

20. a) Calculate the radiation exchange per unit area between two parallel plates of temperature 4000C and 250C. Emissivity of hot and cold plates are 0.9 and 0.7 respectively. Find the percentage reduction in heat transfer, if a radiation shield of emissivity 0.25 is placed in between the plates

(7 marks)

b) Explain Wien's displacement law? (7 marks)

Syllabus

Module 1- INTRODUCTION TO HEAT TRANSFER

Modes of Heat Transfer: Introduction to Conduction, Convection, radiation. Conduction: Fourier law of heat conduction-Thermal conductivity of solids, liquids and gases-Factors affecting thermal conductivity- Most general heat conduction equation in Cartesian and cylindrical coordinates.

Module 2 CONDUCTION HEAT TRANSFER

One dimensional steady state conduction with and without heat generation conduction through plane walls, cylinders. Critical thickness of insulation – Heat transfer through composite wall- extended surface heat transfer – fin performance – effect of variable thermal conductivity.

Module 3 CONVECTION HEAT TRANSFER

Convection heat transfer: Newton's law of cooling- Free and forced convection. Laminar and Turbulent flow, Reynolds Number, Critical Reynolds Number, Prandtl Number, Nusselt Number, Grashoff Number and Rayleigh's Number. Elementary ideas of hydrodynamics and thermal boundary layers-Thickness of Boundary layer-Displacement, Momentum and Energy thickness (description only).

Module 4 HEAT EXCHANGERS

Heat exchangers: Classification – log mean temperature difference – overall heat transfer coefficient – fouling and scaling of heat exchangers – LMTD and NTU method of performance evaluation of heat exchangers.

Module 5 RADIATION HEAT TRANSFER

Radiation: Fundamentals of radiation – radiation spectrum – thermal radiation – concept of black body and grey body – monochromatic and total emissive power – absorptivity, reflectivity and transmissivity - laws of radiation – radiation between two surfaces – geometrical factors for simple configuration – radiation shields – electrical network method of solving problems.

Text Books

1. Sachdeva R. C., Fundamentals of Engineering Heat and Mass Transfer, New Age Science Limited

2. R. K. Rajput, Heat and mass transfer, S. Chand & Co.

3. Nag P. K., Heat and Mass Transfer, McGraw Hill.

4. Kothandaraman, C.P., Fundamentals of Heat and Mass Transfer, New Age International, New Delhi.

Data Book

Heat and Mass Transfer data book: C.P. Kothandaraman, S. Subramanyan, New age International publishers.

Reference Books

1. Holman J.P, "Heat transfer", Mc Graw-Hill, 10th. Ed.

2. Yunus A Cengel, "Heat and Mass Transfer: Fundamentals and Applications" McGraw-Hill Higher Education.

3. Frank P. Incropera and David P. Dewitt, Heat and Mass Transfer, John Wiley and sons.

COURSE PLAN

MODULE	TOPICS	HOURS ALLOTED
1	Modes of Heat Transfer: Introduction to Conduction, Convection, radiation. Conduction: Fourier law of heat conduction-Thermal conductivity of solids, liquids and gases-Factors affecting thermal conductivity	**4-0-0**
	General heat conduction equation in Cartesian coordinates. General heat conduction equation in Cylindrical coordinates	**3-1-0**
2	One dimensional steady state conduction with and without heat generation conduction through plane walls, cylinders. Critical thickness of insulation – Heat transfer through composite wall- extended surface heat transfer – fin performance – effect of variable thermal conductivity.	**8-2-0**
	Convection heat transfer: Newton's law of cooling- Free and forced convection. Laminar and Turbulent flow, Reynolds Number, Critical	

3	Reynolds Number, Prandtl Number, Nusselt Number, Grashoff Number and Rayleigh's Number. Elementary ideas of hydrodynamics and thermal boundary layers-Thickness of Boundary layer-Displacement, Momentum and Energy thickness	**7-2-0**
4	Heat exchangers: Classification – log mean temperature difference – overall heat transfer coefficient – fouling and scaling of heat exchangers – LMTD and NTU method of performance evaluation of heat exchangers	**8-2-0**
5	Radiation: Fundamentals of radiation – radiation spectrum – thermal radiation – concept of black body and grey body – monochromatic and total emissive power – absorptivity, reflectivity and transmissivity - laws of radiation – radiation between two surfaces – geometrical factors for simple configuration – radiation shields – electrical network method of solving problems.	**7-2-0**

MET386	INDUSTRIAL ENGINEERING	CATEGORY	L	T	P	CREDIT
		VAC	3	1	0	4

Preamble: This course helps an engineering student to understand the functions and techniques of Industrial Engineering. It addresses economic aspects of the business decision and the concepts of human factors in design. The course involves productivity improvement methods, Work study, Method study and Time study. Industrial Engineering Tools and Techniques for Plant management including Plant layout and Material handling are also covered in this course. The students also will able understand Production Planning and Control process, and procedures. The other focus areas of Industrial Engineering, Quality practices, Project Management and Replacement technique are also part of this course.

Prerequisite: NIL

Course Outcomes: After the completion of the course the student will be able to

CO 1	Understand the functions of Industrial Engineering, Economic aspects of business and Human factors in design
CO 2	Apply Principles of Work study, Method study and Work measurement techniques.
CO 3	Develop layout for a manufacturing/service system and apply plant management and Material handling techniques.
CO 4	Evaluate Production Planning and Control techniques and Inventory control
CO 5	Analyse Quality practices, and Apply Project Management and Replacement techniques.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1			2			3	3				3	
CO 2		3	3			3						
CO 3		3	3		3							
CO 4		3	3	3	3						3	
CO 5		3	3	3		3	3				3	

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	10
Understand	20	20	20
Apply	20	20	70
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks

Continuous Assessment Test (2 numbers) : 25 marks

Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. State functions of an Industrial Engineer which will lead to improvement in productivity?.

2. How the productivity of s system can be improved? List factors affecting productivity that can be controlled.

3. Asian industries specialize in the manufacture of small capacity motors. The cost structure of the motor is as under

Material	Rs 50/-
Labour	Rs 80/-
Variable overhead	75% of labour cost

Fixed cost of the company amount 2,40,000 Rs/annum

The sales price of the motor is Rs 230/- each

Determine the number of motors to be manufactured to break even

How many motors are to be sold to make a profit of Rs 1 Lakh

If the sale price is reduced by Rs. 15/- how many motors are to sold to break even

Course Outcome 2 (CO2)

1. What is the concept of work content? What are reasons for excess of work content?

2. Differentiate between Two hand process chart and Multiple Activity chart.

3. The following data refers to the study conducted for an operation. The table shows the actual time for elements in minutes.

Cycle elements	1	2	3	4	5
1	2.5	2.6	2.4	2.5	2.5
2	6.0	6.2	6.1	5.9	6.0
3	2.3	2.1	2.4	2.2	2.3
4	2.4	2.5	2.6	2.8	2.5

i) Element 3 is machine elements

ii)Take performance rating as 110

Take following personal allowance of 30 minutes in shift of 8 hours, fatigue allowance 15%, contingency allowance 2%. Estimate the standard time for the operation and production per 8 hour shift.

Course Outcome 3(CO3):

1. List the different types of layout. Differentiate between Product and process layout based any five parameters.

2. Consider the following assembly network relationships of a product. The number of shifts per day is two and the number of working hours per shift is 8. The company aims to produce 80 units of the product per day. Group the activities into work stations using Ranking Positional Weight method and compute balancing efficiency.

Operation Number	Immediate predecessor	Duration (Min)
1	-	7
2	1	2
3	1	2
4	1	5
5	2,3	8
6	3,4	3
7	5	4
8	5,6	7
9	4,6	9
10	7,8,9	8

3. The initial cost of an equipment is Rs 21000/- expected salvage value Rs 1000 and expected useful life of 10 years. Calculate the depreciation and book value after 1 year and 9 years using sinking fund method and straight line method. Take interest rate as 6%

Course Outcome 4 (CO4):

1. Explain the steps of Production planning Process,

2. Describe the importance Product Life cycle in Product development and Management

3. A manufacturer has to supply his customer a 2400 units of his products per year. Shortages are not permitted. Inventory carrying cost amounts to Rs. 0.8/- per unit per annum. The setup cost per run is Rs 60/- . Find

i. EOQ

ii. Optimum number of order per annum

iii. Average annual inventory cost(min)

iv. Optimum period of supply per order

Course Outcome 5 (CO5):

1. Explain the Procedure of X and R chart .

2. The mortality rate are given in the table below for certain type of electric bulb. There are 2000 bulb in use and it costs Rs 12/- to replace an individual bulb that has burnt. If all the bulbs are replaced simultaneously, it would cost Rs. 4/- per bulb. It is proposed to replace all the bulbs in fixed intervals, whether or not they have burnt out and to continue replacing burnt bulbs out bulbs if they fail. At what intervals should all the bulbs be replaced?

Week	1	2	3	4	5	6
Probability of failure	0.05	0.2	0.25	0.3	0.15	0.05

Model Question paper

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
SIXTH SEMESTER B.TECH DEGREE EXAMINATION

Course Code : MET386

Course Name : **INDUSTRIAL ENGINEERING**

Max. Marks : 100 Duration : 3 Hours

Part A

(**ANSWER ALL QUESTIONS, EACH QUESTION CARRIES 3 MARKS**)

1. What are the factors influencing productivity?
2. Explain the role ergonomics plays in environmental man-machine interface
3. What is micro motion study? What are the steps involved?
4. Explain flow diagram with example
5. Explain REL Chart
6. Explain the criteria for selecting Material handling equipment
7. How order promising is done during Production planning
8. Briefly explain any three selective inventory control techniques

9. Explain the significance of Bathtub curve
10. Briefly explain the stages of TQM implementation

Part B

(ANSWER ONE FULL QUESTION FROM EACH MODULE)

Module 1

11. **a)** Explain the factors affecting make or buy decisions. (7marks)

b) ABC company plans to sell an article at local market. The articles are purchased at Rs 5 on the condition that all unsold items shall be returned. The rent for the space Rs 2000. The article will be sold at Rs 9 . Determine the number of articles which must be sold to i) to break even ii) to earn Rs 400 profit iii)if the company sells 750 articles . Calculate the margin of Safety (7 marks)

12. a) Explain the principles in the application of Anthropometric data. How it can be used in work place design? (8 marks)

b) Explain the functions of Industrial Engineering (6 Marks)

Module 2

13. a) Explain the use recording techniques in method study. Differentiate between Operations Process chart and Flow process chart. (7 Marks)

b) The observed time and the performance rating for five elements are given. Compute the standard time assuming rest and personal allowance as 15% and contingency as 2% of basic time.

Element	**1**	**2**	**3**	**4**	**5**
Observed	0.2	0.08	0.50	0.12	0.10
Performance rating	85	80	90	85	80

(7 Marks)

14 a) Explain the different techniques used for work measurement. (7 Marks)

b) The following data refers to the study conducted for an operation. The table shows the actual time for elements in minutes.

Cycle elements	1	2	3	4	5
1	2.5	2.6	2.4	2.5	2.5
2	6.0	6.2	6.1	5.9	6.0
3	2.3	2.1	2.4	2.2	2.3
4	2.4	2.5	2.6	2.8	2.5

i) Element 3 is machine elements

ii)Take performance rating as 110

Take following personal allowance of 30 minutes in shift of 8 hours, fatigue allowance 15%, contingency allowance 2%. Estimate the standard time for the operation and production per 8 hour shift. (7 Marks)

Module 3

15. a) Explain Systematic Layout planning with the help of block diagram. (6 Marks)

b) Consider the following assembly network relationship of a product. The number of shifts per day is two and the number of working hours per shift is 12. The company aims to produce 100 units of the product per day. Group the activities into work stations using Rank Positional Weight Method and compute balancing efficiency.

Operation number	Immediate preceding Tasks	Duration (Min)
1	-	7
2	1	2
3	1	2
4	1	5
5	2,3	8
6	3,4	3

7	5	4
8	5,6	7
9	4,6	9
10	7,8,9	8

(8 Marks)

16 a) The initial cost of an equipment is Rs 21000/- expected salvage value Rs 1000 and expected useful life of 10 years. Calculate the depreciation and book value after 1 year and 9 years using sinking fund method and straight line method. Take interest rate as 6%. (6 Marks)

b)The price of an office equipment is Rs 2.5 lakhs the salvage value at the end of 10 years is Rs 25,000/ Calculate the amortised value after 5 years by using i) sinking fund method ii) declining balance method. (8 Marks)

Module 4

17 a) What are the different types of Production system, explain (7 Marks)

b)Consider the following 3 machine and 5 jobs flow shop problem. Check whether Johnson's can be extended to this problem. What is the optimal schedule for this problem and corresponding makespan? Draw the Gantt chart.

Job	Machine 1	Machine 2	Machine 3
1	11	10	12
2	13	8	20
3	15	6	15
4	12	7	19
5	20	9	7

(7 Marks)

18 a) Explain the Product Life cycle and its importance in Product management. (7 Marks)

b) ABC industry needs 15,000 units/year of a bought out component which will be used in its main product. The ordering cost is Rs. 125 per order and holding cost per unit per year is 20% of the purchase price per unit which is Rs. 75.

i. Find economic order quantity

ii. Number of order per year

iii. Time between successive orders

The activities involved in ABC manufacturing company are listed below with their time estimates. Draw the network for the given activities and carry out critical path calculations.

(7 Marks)

Module 5

19 a) Differentiate between PERT and CPM, Specify the difference in application (6 Marks)

b) Consider the following data of the project

Activity	Predecessor	Duration (Weeks)		
		a	m	b
A	_	3	5	8
B	_	6	7	9
C	A	4	5	9
D	B	3	5	8
E	A	4	6	9
F	C,D	5	8	11
G	C,D,E	3	6	9
H	F	1	2	9

i. Construct the project network

ii. Find expected duration and variance of each activity

iii. What is the probability of completing the project in 30 weeks?

(8 Marks)

20 a) What is Process Capability? Explain the significance Process capability Index

(7 Marks)

b)The cost of a machine is Rs. 60,000/-. The salvage value and the running costs of a machine are shown in the table. Depreciation is cumulative. Find the most economical replacement age of the machine. (7 marks)

Year	1	2	3	4	5	6
Running cost in Rs.	12050	14100	16375	18875	20500	24550
Resale value in Rs	40000	30000	25000	15000	10500	7000

Syllabus

Module 1

Introduction to Industrial Engineering - Evolution of modern Concepts in Industrial Engineering - Functions of Industrial Engineering.
Productivity- productivity measures- dynamics of productivity change- Techniques for improving productivity.
Production costs concepts – Manufacturing Vs Purchase- problems- Economic aspects- C-V-P analysis – simple problems..
Ergonomics Man-Machine systems-Anthropometry Work place design and ergonomics - Value Engineering.

Module 2
Work study-procedure-concept of work content- techniques to reduce work content.
Method Study-steps-recording techniques-operation process chart-flow process chart-two hand process chart-multiple activity chart. Diagrams- Flow diagrams-String diagrams. Micro-motion study-SIMO chart- critical examination. Principle of motion economy.
Work measurement- techniques of work measurement - Time Study- - Steps in time study-calculation of standard time (problems)- allowances.

Module 3
Plant location, plant layout and material handling- Type of layouts and characteristics –Tools and techniques for plant layout- travel chart – REL chart- Computer algorithms for layout design CRAFT-ALDEP (methods only)- Systematic layout planning -Line balancing–RPW (problem).
Principles of material handling-selection and type of material handling equipment- Unit load concept- Automated Material Handling Systems- AGVs.
Depreciation -Method of providing for depreciation- straight line method- Declining balance method- Sinking fund methods (Problems)

Module 4
Production Planning and control -Types of Production systems.
Demand forecasting- Forecasting methods, Aggregate planning- methods- Master Production Schedule-techniques-order promising- Material Requirement Planning-bill of material-

product structure diagram- MRP record processing- Shop floor control - Scheduling flow shop and job shop scheduling methods, Johnson's algorithm-dispatching rules - Gantt charts. Introduction and need for a new product-product life cycle.
Inventory Control, Inventory models – Basic model -price discounts -problems – determination of safety stock - Selective inventory control techniques

Module 5

Quality control - Statistical quality control –causes of variation in quality- control charts for X and R (problems). Process Capability- process capability index- Reliability-causes of failures- Bath tub curve.-System reliability. Introduction to concepts of, TQM, ISO, Six Sigma and Quality circles.
Project management- Critical Path Method, PERT, crashing of networks
Determination of economic life -Replacement policy-- Methods of replacement analysis.

Text Books

1. Martand Telsang, Industrial Engineering & Production Management, S. Chand, Third revised edition 2018.
2. B. Kumar, Industrial Engineering Khanna Publishers, Tenth Edition 2015
3. Thomas E Vollmann , William L Berry , D Clay Whybark, F Robert Jacobs, Manufacturing Planning and Control for Supply Chain Management, McGraw Hill Education (India) Private Limited, Fifth Edition 2017
4. M Mahajan, Industrial Engineering & Production Management, Dhanpat Rai, 2015
5. O. P. Khanna, Industrial Engineering and Management, Dhanpat Rai, 2018

Reference Books

1. E. S. Buffa, Modern Production management, John Wiley, 1983

2. Grant and Ieven Worth, Statistical Quality Control, McGraw Hill, 2000

3. Ralph M Barnes, Motion and Time Study, Wiley, 1980

4. Richard L. Francis, F. McGinnis Jr., John A. White, Facility Layout and Location: An Analytical Approach, 2nd Edition,1991

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	Introduction to Industrial Engineering - Evolution of modern Concepts in Industrial Engineering - Functions of Industrial Engineering. Productivity- productivity measures- dynamics of productivity change- Techniques for improving productivity. Production costs concepts – Manufacturing Vs Purchase- problems- Economic aspects- C-V-P analysis – simple problems.. Ergonomics Man-Machine systems-Anthropometry Work place design and ergonomics - Value Engineering	7-2-0
2	Work study-procedure-concept of work content- techniques to reduce work content. Method Study-steps-recording techniques-operation process chart-flow process chart-two hand process chart-multiple activity chart. Diagrams- Flow diagrams-String diagrams. Micro-motion study-SIMO chart- critical examination. Principle of motion economy. Work measurement- techniques of work measurement - Time Study- - Steps in time study- calculation of standard time (problems)- allowances	7-2-0
3	Plant location, plant layout and material handling- Type of layouts and characteristics – Tools and techniques for plant layout- travel chart – REL chart- Computer algorithms for layout design CRAFT-ALDEP (methods only)- Systematic layout planning -Line balancing–RPW (problem). Principles of material handling-selection and type of material handling equipment- Unit load concept- Automated Material Handling Systems- AGVs. Depreciation -Method of providing for depreciation- straight line method- Declining balance method- Sinking fund methods (Problems)	7-2-0
4	Production Planning and control -Types of Production systems. Demand forecasting- Forecasting methods, Aggregate planning- methods- Master Production Schedule-techniques-order promising- Material Requirement Planning-bill of material-product structure diagram- MRP record processing- Shop floor control - Scheduling flow shop and job shop scheduling methods, Johnson's algorithm- dispatching rules -- Gantt charts. Introduction and need for a new product-product life cycle. Inventory Control, Inventory models – Basic model -price discounts -problems – determination of safety stock - Selective inventory control techniques	7-2-0
5	Quality control - Statistical quality control –causes of variation in quality- control charts for X and R (problems). Process Capability- process capability index- Reliability-causes of failures- Bath tub curve.-System reliability. Introduction to concepts of, TQM, ISO, Six Sigma and Quality circles. Project management- Critical Path Method, PERT, crashing of networks Determination of economic life -Replacement policy-- Methods of replacement analysis.	7-2-0

SEMESTER VI

HONOURS

CODE MET394	COURSE NAME ADVANCED DESIGN SYNTHESIS	CATEGORY	L	T	P	CREDIT
		VAC	3	1	0	4

Preamble:

- To give an overview of the techniques used in Mechanical Engineering for the analysis and synthesis of Mechanisms.
- To familiarize the graphical and analytical techniques commonly used in the synthesis of mechanisms.
- To provide sufficient theoretical background to understand contemporary mechanism design techniques.
- To develop skills for applying these theories in practice. Identify mechanisms by type of motion (Planar, Spatial etc.)
- Select the best type of mechanism for a specific application and apply the fundamental synthesis technique to properly dimension the mechanism

Course Outcomes: After the completion of the course the student will be able to

CO 1	Analyse Velocity and Acceleration Analysis of complex mechanisms using auxiliary points
CO 2	Solve the synthesis of slider crank mechanism with three accuracy points
CO 3	Explain the synthesis of slider crank mechanism with four accuracy points
CO 4	Describe the algebraic methods of synthesis using displacement equations
CO 5	Demonstrate the algebraic methods of synthesis using complex numbers

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3	2									
CO 2	3	3	2									
CO 3	3	3	2									
CO 4	3	3	2									
CO 5	3	3	2									

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	10
Understand	20	20	20
Apply	20	20	70
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Calculate Velocity and Acceleration Analysis of complex mechanisms using auxiliary points.

2. Describe Roberts – Chebyshev theorem.

3. Explain the Inflection circle, Euler- Savery equation, and Hartman construction.

Course Outcome 2 (CO2)

1. Describe about the Relative poles of four bar linkages and slider crank mechanism.

2. List out the usage of Function generators.

3. Execute the synthesis of slider crank mechanism with three accuracy points.

Course Outcome 3(CO3):

1. Execute the geometric methods of synthesis with four accuracy points.

2. Discuss about the Construction of circle points, Cardinal points, opposite poles, and Pole quadrilaterals

3. Do the synthesis of slider crank mechanism with four accuracy points.

Course Outcome 4 (CO4):

1. Demonstrate the algebraic methods of synthesis using displacement equations.

2. Execute the Crank and follower synthesis.

3. Describe the method to get angular velocities and accelerations from crank and follower synthesis.

Course Outcome 5 (CO5):

1. Discuss about the Algebraic methods of synthesis using complex numbers.

2. Explain the importance Spatial motion and spatial linkages.

3. Demonstrate working of the Simple mechanisms in Robots.

MODEL QUESTION PAPER

MECHANICAL ENGINEERING

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
SIXTH SEMESTER B. TECH DEGREE EXAMINATION
Course Code: MET394

Course Name: ADVANCED DESIGN SYNTHESIS
Max. Marks: 100
Duration: 3 Hours

PART – A

(ANSWER ALL QUESTIONS, EACH QUESTION CARRIES 3 MARKS)

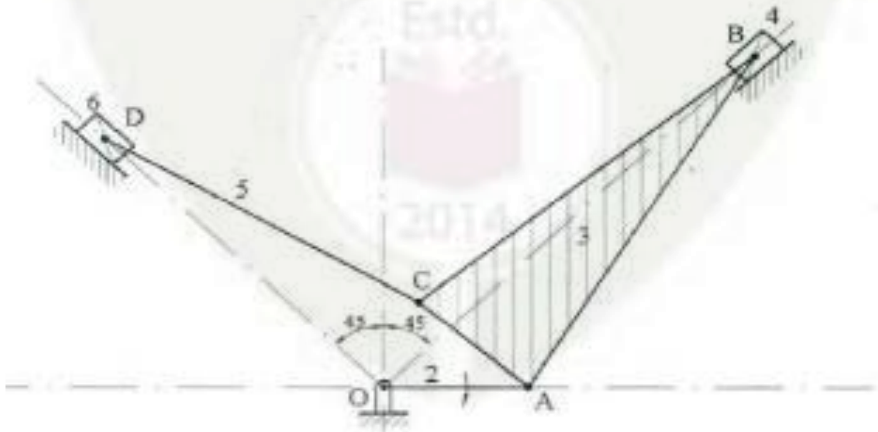
1. State and explain Robert Chebychev theorem?
2. Explain the properties of inflection circle?
3. What are three accuracy points in cam and follower synthesis?
4. Explain the relative poles of slider crank mechanism with sketch?
5. What is the significance function generator in the design of a mechanism?
6. Explain pole quadrilateral in geometric synthesis?
7. Define center point and circle point?
8. Write notes on types of errors in synthesis?
9. Draw a simple robot mechanism?
10. Classify the various types of spatial mechanisms?

PART – B

(ANSWER ONE FULL QUESTION FROM EACH MODULE)

MODULE – 1

11. For the twin cylinder V engine, determine the velocity of pistons B and D and the angular velocity of link 3. Link 2 rotates at 2000rpm. The dimensions of the various links are: O2A = 50mm ; AB = BC = 150mm ; AC =50mm ; CD = 125mm



(14 marks)

12. 12. Using overlay method and Chebychev spacing design a four-bar mechanism to generate the function $y = x^{1.5}$ for $0.5 < x < 1.5$. Assume six precision points. (14 marks)

Module 2

13. a) Discuss the significance of transmission angle in the design of a four-bar mechanism. (6 marks)

    b) Explain the procedure for design of a four-bar mechanism for optimum transmission angle.

    (8 marks)

14. Design a function generator linkage to solve y = 1/x in the range 1 < x < 2 using three precision points using geometric method. $\Delta\Phi = 90^o$, $\Delta\Psi = 90^o$, $\Phi_0 = 90^o$, $\Psi_0 = 45^o$. Plot a curve of the desire function and the one generated by the synthesized linkage and find the maximum error percentage. (14marks)

Module 3

15. Design a slider crank mechanism such that $\Phi_{12} = 30^o$ and $\Phi_{23} = 50_o$ and S_{12} = 25 cm and S_{23} = 20 cm using geometric method. The input crank moves in clockwise direction and the slider moves away from the crank pivot. (14 marks)

16. Design a double rocker mechanism to generate the function $y = e^x$ in the range 1 ≤ x ≤ 1 using four precision points and Chebychev spacing using geometric method. (14 marks)

Module 4

17. Synthesize a four-bar generator to generate the function $y = \log_{10} x$ in the range 1 ≤ x ≤ 2 using algebraic method. Assume suitable starting angles and ending angles for motion of input and output links. Use three precision points and Chebychev spacing. Find out the maximum error. (14marks)

18. Synthesize a four-bar linkage to meet the following specification of position, velocity and acceleration

    $\Phi = 60^o$ $\Psi = 90^o$

    ω_Φ = 5 rad/s ω_Ψ = 2 rad/s

    α_Φ = 2 rad/s2 α_Ψ = 7 rad/s2 (14 marks)

Module 5

19. Synthesize a four-bar linkage to satisfy the following specifications:

    ω_2 = 200 rad/s, ω3 = 85 rad/s, ω_4 = 130rad/s

    α_2 = 0 rad/s^2, α3 = -1000 rad/s^2, α_4 = -1600 rad/s^2 (14 marks)

20. Compute the link lengths of a four-bar mechanism that will in one of its positions satisfy the following specifications: ω_1 = 8 rad/sec, α_1 = 0, ω_2 = 1 rad/sec, α_2 = 20 rad/sec^2, ω_3 = -3 rad/sec, α_3 = 0. (14 marks)

Syllabus

Module 1

Floating Link, Special methods of velocity and acceleration analysis using auxiliary points.Overlay method for conditioned crank mechanisms, coupler curves.

Roberts – Chebyshev theorem. Inflection circle, Euler- Savery equation, Hartman construction, Bobillier construction.

Module 2

Synthesis using Optimum transmission angle.

Geometric methods of synthesis with three accuracy points: - poles of four bar linkages, Relative poles of four bar linkages, Function generators, poles of slider crank mechanisms, Relative poles of slider crank Mechanisms, Rectilinear recorder mechanisms.

Synthesis of slider crank mechanism with three accuracy points.

Module 3

Geometric methods of synthesis with four accuracy points: - pole triangles, center point curves, Circle point curves, Construction of circle points, Cardinal points, opposite poles, Pole quadrilaterals,

Function Generators, Synthesis of slider crank mechanism with four accuracy points.

Module 4

Algebraic methods of synthesis using displacement equations: - Crank and follower synthesis- three accuracy points.

Crank and follower synthesis- angular velocities and accelerations.

Module 5

Rectilinear mechanisms, Algebraic methods of synthesis using complex numbers. Spatial motion and spatial linkages. Types of spatial mechanisms, Single loop linkage and multiple loop linkages. Simple mechanisms in robots.

Text Books

1. Kinematic synthesis of Linkages by Richard.S.Hartenberg, Jacques Denavit, McGraw Hill book company. 1964

2. Kinematics and linkage design by Allen.S.Hall. Prentice Hall of India, Ltd. 1986

3. Theory of Mechanisms and Machines by Shigley, McGraw Hill International Edition., 4th edition, 2014

4. Dynamics of Machinery by A.R.Holowenko. John Wiley & Sons Inc, 1955

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Module 1**	
1.1	Floating Link, Special methods of Velocity and Acceleration Analysis using auxiliary points.	3
1.2	Overlay method for conditioned crank mechanisms, coupler curves. Roberts – Chebyshev theorem	3
1.3	Inflection circle, Euler- Savery equation, Hartman construction, Bobillier construction. Synthesis using Optimum transmission angle	3
2	**Module 2**	
2.1	Geometric methods of synthesis with three accuracy points: - poles of four bar linkages, Relative poles of four bar linkages,	3
2.2	Function generators, poles of slider crank mechanisms, Relative poles of slider crank Mechanisms, Rectilinear recorder mechanisms.	3
2.3	Synthesis of slider crank mechanism with three accuracy points.	3
3	**Module 3**	
3.1	Geometric methods of synthesis with four accuracy points: - pole triangles, center point curves,	3
3.2	Circle point curves, Construction of circle points, Cardinal points, opposite poles, Pole quadrilaterals,	3
3.3	Function Generators, Synthesis of slider crank mechanism with four accuracy points.	3
4	**Module 4**	
4.1	Algebraic methods of synthesis using displacement equations: - Crank and follower synthesis- three accuracy points	4
4.2	Crank and follower synthesis- angular velocities and accelerations	4
5	**Module 5**	
5.1	Rectilinear mechanisms, Algebraic methods of synthesis using complex numbers.	3
5.2	Spatial motion and spatial linkages	3
5.3	Types of spatial mechanisms, Single loop linkage and multiple loop linkages. Simple mechanisms in Robots.	3

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
MET 396	COMPRESSIBLE FLUID FLOW	VAC	3	1	0	4

Preamble:

The objectives of the course are:

- To introduce the fundamental concepts involved in compressible flow.
- To apply the fundamental laws to one dimensional compressible isentropic flow for the design of convergent and divergent nozzles.
- To solve the problems of compressible flow in constant area duct involving friction and heat transfer.
- To understand the flow mechanism before and after the normal/oblique shocks
- To introduce various measurement and visualisation techniques in compressible flows.

Prerequisite: MET203 Mechanics of fluid, MET202 Engineering Thermodynamic

Course Outcomes: After the completion of the course the student will be able to

CO 1	Explain the fundamental concepts involved in compressible flow
CO 2	Formulate and solve typical problems in one dimensional isentropic compressible flow by use of the appropriate equations and tables.
CO 3	Solve typical problems of flow in constant area duct with friction
CO 4	Solve typical problems of flow in constant area duct with friction
CO 5	Calculate the change in flow properties across normal and oblique shock waves.
CO 6	Illustrate different techniques used in measurement and visualization of compressible flows

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3										2
CO 2	3	3	2	2								3
CO 3	3	2	2									1
CO 4	3	2	2	1								
CO 5	3	2										2
CO 6	3	3										

Assessment Pattern

Bloom's Category	Continuous Assessment			End Semester Examination
	Assignment (%)	Test 1 (%)	Test 2 (%)	
Remember	25	20	20	10
Understand	25	40	40	20
Apply	25	40	40	70
Analyse	25			
Evaluate				
Create				

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Represent various flow regimes on steady flow adiabatic ellipse.
2. List the various conservation laws governing the compressible flow
3. Define Mach cone and Mach Angle

Course Outcome 2 (CO2)

1. Express stagnation enthalpy in terms of static enthalpy and velocity of flow
2. Explain the phenomenon of choking in isentropic flow.
3. Write applications of convergent nozzles and convergent-Divergent nozzles

Course Outcome 3 (CO3):

1. Describe the phenomenon of frictional chocking
2. Differentiate between Fanno flow and Isothermal flow

3. Explain the significance of critical length in Fanno flow

Course Outcome 4 (CO4):

1. Explain the process of thermal chocking in Rayleigh flow
2. Under what conditions the assumptions of Rayleigh flow is not valid in a heat exchanger
3. Locate the maximum enthalpy point in Rayleigh flow

Course Outcome 5 (CO5):

1. State and prove Prandtl-Mayer relationship for a normal shock wave.
2. What is an expansion fan? How does it occur in supersonic flow?
3. Explain why shock is impossible in subsonic flow.

Course Outcome 6 (CO6):

1. Name the various types of wind tunnels used for low and high speed testing of models
2. Difference between working principle of Shadowgraph and Schlieren techniques
3. Explain the working principle of constant current hot wire anemometer

MODEL QUESTION PAPER

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SIXTH SEMESTER MECHANICAL ENGINEERING

Compressible Fluid Flow -MET396

Maximum: 100 Marks **Duration: 3 hours**

PART A

Answer all questions. Each question carries 3 marks

1. Derive an expression for stagnation temperature in terms of Mach number for compressible fluid flow.
2. Derive the condition at which flow become choked in isentropic flow?
3. Prove that Mach number is unity at the maximum entropy point on a Fanno curve.
4. Explain the significance of critical length in Fanno flow
5. What is Rayleigh flow? Explain Rayleigh flow with one practical case.
6. Under what conditions the assumptions of Rayleigh flow is not valid in a heat exchanger
7. Explain two situations where a normal shock wave is formed

8. Explain the formation of oblique shock wave in a concave corner and expansion fan in convex corner

9. Mention the difference in principle of the shadowgraph and Schlieren system

10. Explain with the help of sketches how yaw angle is eliminated in a Kiel probe.

(10 X 3 = 30 Marks)

PART B

Answer one full question from each module

MODULE 1

11.a. An air nozzle is to be designed for an exit Mach number of 2. conditions of the air available in the reservoir are 700 kPa, 533 K. Estimate i) pressure ii) temperature iii) velocity of flow iv) area, at throat and exit of the nozzle. Mass flow rate through the nozzle is 10000 kg/hr. 10 marks

b. Derive an expression for area ratio in terms of Mach number for isentropic flow. Explain graphically the variation of area ratio with Mach number. 4 marks

12.a. Derive the conservation of mass equation for compressible flow through control volume approach. 4 marks

b. A perfect gas having Cp = 1017.4 J/kg and molecular weight 28.97 flows adiabatically in a converging passage with a mass flow rate if 27.20kg/s. At a particular location, M = 0.5, T = 500K and p = 0.25 MPa. Calculate the area of cross section of the duct at the location.

10 marks

MODULE II

13.a. A circular duct passes 8.25 kg/s of air at an exit Mach number of 0.5. The entry pressure and temperature are 3.45 bar and 38^{o}C respectively and the mean coefficient of friction 0.005. If the Mach number at the entry is 0.15, determine i) diameter of the duct, ii) length of duct, iii) pressure and temperature at exit and iv) stagnation pressure loss. 8 marks

b. Differentiate between Fanno flow and isothermal flow. Give one practical example each for Fanno flow and isothermal flow. 6 marks

14.a. Explain the phenomenon of choking in Fanno flow. 4 marks

b. Air enters, a long circular duct of diameter 12 cm and mean coefficient of friction 0.0045, at a Mach number of 0.5, pressure 3.5 bar and temperature 300 K. If the flow is adiabatic throughout the duct, determine i) the length of the pipe required to change the Mach number to 0.6 ii) pressure and temperature of air at M=0.6 iii) the length of the pipe required to attain limiting Mach number iv) pressure, temperature and Mach number at the limiting condition 10 marks

MODULE III

15.a. Derive an equation describing a Rayleigh curve. Show that at maximum entropy point the flow is sonic. 6 marks

b. Data for entry of air at a constant area duct are p1 = 0.35 bar, T1 = 300 K, velocity of gas c1 = 60 m/s. If 620 kJ/kg if heat is added to the gas in the duct between entry and exit sections, determine at the exit i) pressure ii) temperature iii) Mach number iv) velocity of gas. How much heat is required to accelerate air from initial condition to sonic condition? 8 marks

16.a. Derive an expression for maximum possible heat transfer in Rayleigh flow in terms of Mach number. 7 marks

b. Air at Mach 1.5, pressure 300kPa and temperature 288K is brought to sonic velocity in a frictionless constant area duct through heat transfer. Determine the final pressure, temperature and heat added during the process. 7 marks

MODULE IV

17.a. Derive an expression for Mach number downstream of a normal shock 7 marks

b. The ratio of exit to entry area in a subsonic diffuser is 3.3. The Mach number of a jet of air approaching the diffuser is 2.1. Stagnation pressure of the jet is 1.1 bar and its static temperature is 330 K. There is a standing normal shock wave just outside the diffuser entry. The flow in the diffuser is isentropic. Determine pressure, temperature and Mach number at the exit of the diffuser. Also find the loss in stagnation pressure of the jet as it passes through the diffuser. 7 marks

18. a. What is an expansion fan? How does it occur in supersonic flow? 5 marks

18b. A stationary normal shock occurs in an air stream when the pressure, temperature and Mach number are 85 kPa, 110 ^{0}C and 1.7 respectively. Determine its density after the shock. Compare this value in an isentropic compression through the same pressure ratio. 9 marks

MODULE V

19 a. Explain the working of a shock tube with a neat sketch 8 marks

b. Explain the working of a constant current hot wire anemometer used for flow velocity measurement. 6 marks

20 a. Describe with the aid of a schematic diagram the working of a closed circuit supersonic wind tunnel. 7 marks

b. With a neat sketch explain the working of stagnation temperature probe. 7 marks

Module 1- FUNDAMENTALS OF COMPRESSIBLE FLOW & ISENTROPIC FLOW

Fundamentals of compressible flow: Concept of continuum-system and control volume approach- conservation of mass, momentum and energy- Mach number and its significance- Mach waves- Mach cone and Mach angle- physical difference between incompressible, subsonic, sonic and supersonic flows- static and stagnation states- relationship between stagnation temperature, pressure, density and enthalpy in terms of Mach number- Reference states in compressible fluid flows - adiabatic energy equation-representation of various flow regimes on steady flow adiabatic ellipse.

One Dimensional Isentropic flow: General features of isentropic flow- Comparison of adiabatic and isentropic process- One dimensional isentropic flow in ducts of varying cross-section- nozzles and diffusers- mass flow rate in nozzles- critical properties and choking- area ratio as function of Mach number- Impulse function- operation of nozzle under varying pressure ratios –over expansion and under expansion in nozzles-Applications of convergent divergent nozzles- Use of gas dynamics tables.

Module 2 FANNO FLOW

Flow in constant area duct with friction (Fanno flow): Fanno curve and Fanno flow equations - Fanno line on h-s and p-v diagram- variation of flow properties- variation of Mach number with duct length- Chocking due to friction- isothermal flow in constant area duct with friction- Use of gas dynamics tables.

Module 3 RAYLEIGH FLOW

Flow through constant area duct with heat transfer (Rayleigh Flow): Rayleigh line on h-s and p-v diagram-location of maximum enthalpy point- thermal chocking-and maximum heat transfer- variations of flow properties- Use of gas dynamics tables.

Module 4 NORMAL & OBLIQUE SHOCK WAVES

Normal shock Waves: Development of shock wave- governing equations- Strength of shock waves- Normal Shock on T-S diagram -Prandtl-Mayer relation, Rankine-Hugoniot relation- Mach number in the downstream of normal shock- variation of flow parameters across the normal shock -normal shock in Fanno and Rayleigh flows- working formula- curves and tables

Oblique shock waves: weak and strong oblique shocks-shock polar diagram-expansion waves- Reflection and intersection of oblique shocks and expansion waves

Module 5 MEASUREMENT & VISUALIZATION TECHNIQUES

Compressible flow field measurement & visualization - Shadowgraph- Schlieren technique- interferometer- subsonic and supersonic flow measurement (Pressure, Velocity and Temperature) – compressibility correction factor- hot wire anemometer- Rayleigh Pitot tube- wedge probe- stagnation temperature probe- temperature recovery factor –Kiel probe - Wind tunnels – closed and open type- sub sonic – supersonic wind tunnels – shock tube.

Text Books

1. Fundamentals of Compressible flow, S. M. Yahya, New age international Publication, Delhi

2. Fundamentals of compressible fluid dynamics- P. Balachandran, PHI Learning, New Delhi

4. Gas Dynamics, E. Rathakrishnan, PHI Learning Pvt. Ltd

5. Gas Dynamics and Jet Propulsion- P. Murugaperumal, Scitech Publication, Chennai.

Data Book

1. Yahya S. M., Gas Tables, New Age International.

2. Balachandran P., Gas Tables, Prentice-Hall of India Pvt. Limited.

Reference Books

1. The dynamics and thermodynamics of Compressible fluid flow Volume-I, Ascher H. Shapiro, the Ronald Press Company, New York.
2. Modern Compressible Flow: With Historical Perspective, John D. Anderson, McGraw-Hill Higher Education

COURSE PLAN

MODULE	**TOPICS**	**HOURS ALLOTED**
1	Concept of continuum-system and control volume approach- conservation of mass, momentum and energy	**3-1-0**
	Mach number and its significance- Mach waves- Mach cone and Mach angle- physical difference between incompressible, subsonic, sonic and supersonic flows- static and stagnation states- relationship between stagnation temperature, pressure, density and enthalpy in terms of Mach number- stagnation velocity of sound- adiabatic energy equation- representation of various flow regimes on steady flow adiabatic ellipse	**2-1-0**
	General features of isentropic flow- performance curve- Comparison of adiabatic and isentropic process- One dimensional isentropic flow in ducts of varying cross-section- nozzles and diffusers- mass flow rate in nozzles- critical properties and choking- area ratio as function of Mach number- Impulse function- operation of nozzle under varying pressure ratios –over expansion and under expansion in nozzles-Applications of convergent divergent nozzles-Working charts and gas tables.	**4-1-0**
2	Fanno curve and Fanno flow equations - Fanno line on h-s and P-v diagram- solution of Fanno flow equations- variation of flow properties- variation of Mach number with duct length- Chocking due to friction- tables and charts for Fanno flow- isothermal flow in constant area duct with friction.	**4-2-0**
	Flow through constant area duct with heat transfer (Rayleigh Flow): Simple heating relation of a perfect gas- Rayleigh line on h-s and P-v diagram-location of maximum enthalpy point- thermal chocking-and maximum heat transfer- variations of flow properties- tables and charts	

3	for Rayleigh flow.	**4-2-0**
4	Development of shock wave- Thickness of shock wave- governing equations- Strength of shock waves- Normal Shock on T-S diagram - Prandtl-Mayer relation, Rankine-Hugoniot relation- Mach number in the downstream of normal shock	**4-1-0**
	variation of flow parameters across the normal shock -normal shock in Fanno and Rayleigh flows- working formula- curves and tables	**2-1-0**
	weak and strong oblique shocks-shock polar diagram-expansion waves- Reflection and intersection of oblique shocks and expansion waves	**2-1-0**
5	Shadowgraph- Schlieren technique-interferometer	**2-0-0**
	subsonic and supersonic flow measurement (Pressure, Velocity and Temperature) – compressibility correction factor- hot wire anemometer- Rayleigh Pitot tube- wedge probe- stagnation temperature probe- temperature recovery factor –Kiel probe - Wind tunnels – closed and open type- sub sonic – supersonic wind tunnels – shock tube	**3-0-0**

CODE MET398	ADVANCED NUMERICAL CONTROLLED MACHINING	CATEGORY	L	T	P	CREDIT
		VAC	3	1		4

Preamble:

This course will help the student to understand the concept of numerical control and the peripheral requirements of the NC system. It familiarise the different approaches of machining using numerical control and also to make the student familiar to the different programming methods of NC machines.

Prerequisite: Nil

Course Outcomes: After the completion of the course the student will be able to

CO 1	To study the structure of numerical control and its applications
CO 2	To understand the features and control of CNC
CO 3	To write numerical part program of simple machining
CO 4	To familiarize the structure of computer assisted part programming features
CO 5	To study the constructional and automated features of numerical controlled machining

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	**2**										2	2
CO 2	**2**				3							2
CO 3	**3**	**2**	2								2	1
CO 4	**3**				2							2
CO 5	**3**		2		3						1	2

Assessment Pattern

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination**
	1	**2**	
Remember	10	10	10
Understand	20	20	20
Apply	20	20	70
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Describe the structure of NC system

2. Enumerate difference between ordinary and NC Machine tools.

3. What is Machining Capabilities of a CNC Machine,.

Course Outcome 2 (CO2)

1. Differentiate open and closed loop control system

2. Enlist features of CNC and DNC system

3 Define the adaptive control system

Course Outcome 3(CO3):

1 Define the structure of CNC part programme

2. What is Programming using tool nose radius compensation ,Tools offsets

3. Enlist the procedure of manual Programming for simple parts

Course Outcome 4 (CO4):

1. Enumerate the structure of computer assisted part programming .

2. Generation of NC Programmes through CAD/CAM systems,.

3. Post processor design and implementation

Course Outcome 5 (CO5):

1. Machine structure of CNC machines

2. Constructional features of CNC turning center and CNC machining center

3. Design consideration of CNC machines

MODEL QUESTION PAPER
APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
SIXTH SEMESTER B.TECH DEGREE EXAMINATION
Course Code : MET398
Course Name : ADVANCED NUMERICAL CONTROLLED MACHINING

Max. Marks : 100 Duration : 3 Hours

PART – A
(*ANSWER ALL QUESTIONS, EACH QUESTION CARRIES 3 MARKS*)

1 How does the structure of NC/CNC machine tools differ from conventional machine tools.
2 Explain clearly the difference between NC and CNC machine
3 Differentiate open loop and closed loop system in CNC machine.
4 Enumerate advantages and disadvantages of Direct numerical control
5 What is GO2 and GO3 in circular interpolation.
6 What is tool nose radius compensation and how to use it.
7 What is CAPP and discuss the benefits of CAPP
8 Discuss the code is used for canned cycle definition
9 Explain briefly swarf removal process in CNC machine.
10 What are the types of tools holders in CNC machine

PART – B
(*ANSWER ONE FULL QUESTION FROM EACH MODULE*)

Module- 1

11 a) With schematic diagram explain the basic principal of numerical. (8 Marks)
b) Explain the historical development of numerical controlled machining (6 Marks)
12 a) Explain the machining capabilities of a CNC machine tool (7 Marks)
b) Enlist and describe the advantages and dis advantages of CNC Machine (7 Marks)

Module-2

13 a) Describe the basic system of CNC machine tool (7Marks)

b) Explain programming features of CNC system (7Marks)

14 a) What is adaptive control system in CNC machining and what is its benefits (7Marks)

b) Describe the standard controllers of CNC machines (7Marks)

Module-3

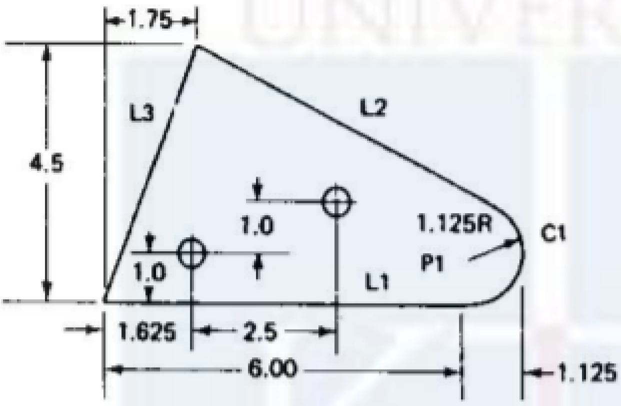
15 a) Explain the structure of NC part program (7Marks)

b) Describe the various programing functions of NC machining (7Marks)

16 a) Explain the fundamental element for developing manual part programme. (7Marks)
b) Describe various G code and M codes of NC programming. (7Marks)

Module-4

17 Write the APT program of a given basic geometry element (14Marks)



18 a) Explain the features CNC post processor. (8Marks)

b) Explain the generation of NC program through CAD/CAM system (6Marks)

Module-5

19 a) Explain Automatic tool changers and multiple pallet systems in CNC system(7Marks)

b) Describe the constructional details of CNC turning centre (7Marks)

20 a) Explain various tooling requirement of CNC system (6Marks)

b) What is CNC tool holder and what are the different types (8Marks)

Module 1

Principles of Numerical Control Structure of NC systems, Applications of CNC machines in manufacturing, Advantages of CNC machines. Historical developments and future trends. Future of NC Machines, Difference between ordinary and NC Machine tools, Machining Capabilities of a CNC Machine, Methods for improving accuracy and productivity.

Module 2

Control of NC Systems: Classification of CNC control systems Open and Closed loop systems, Types of CNC Machine Tools systems devices, e.g. encoders and interpolators, Features of CNC Systems, Direct Numerical Control (DNC), Standard Controllers and General Programming features available in CNC Systems, Computer Process monitoring and Control. Adaptive control systems.

Module 3

NC Part Programming: Axis identification and coordinate systems ,Structure of CNC part program, Programming codes, Programming for 2 and 3 axis control systems ,Manual part programming for a turning center ,Programming using tool nose radius compensation ,Tools offsets ,Do loops, sub routines and fixed cycles. Manual Programming for simple parts.

Module 4

Computer aided part programming; Tools for computer aided part programming, Computer aided NC Programming in APT language, use of canned cycles, Generation of NC Programmes through CAD/CAM systems, Design and implementation of post processors.

Module 5

Constructional Details of CNC Machines: Machine structure ,Slide –ways ,Motion transmission elements ,Swarf removal and safety considerations ,Automatic tool changers and multiple pallet systems, Sensors and feedback devices in CNC machines ,Constructional detail of CNC turning center and CNC machining center. **Tooling of CNC Machines** Tooling requirements of CNC machines, Pre-set and qualified tools, Work and tool holding devices in CNC machines. Design considerations of CNC machines.

Text Books

1. Radhakrishnan, P., “Computer Numerical Control Machines”, New Central Book Agencies
2. Mikell P. Groover., “ Automation, Production Systems and Computer Integrated Manufacturing”, Prentice Hall.

Reference Books

1 YoramKoren, “Computer Control of Manufacturing Systems”, Tata McGraw Hill Book Co.,2005.

2 HMT, Mechatronics, Tata McGraw-Hill Publishing Company Limited, New Delhi,1998.

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Course Contents and Lecture Schedule

No	Topic	No. of lectures
1	**Module-1- Principles of Numerical Control**	**8 Hours**
1.1	Structure of NC systems, Applications of CNC machines in manufacturing,	**2** Hr
1.2	Advantages of CNC machines. Historical developments and future trends.	1 Hr
1.3	Future of NC Machines,	1 Hr
1.4	Difference between ordinary and NC Machine tools,	1 Hr
1.5	Capabilities of a CNC Machine	1 Hr
1.6	Methods for improving accuracy and productivity	2 Hr
2	**Module 2-Control of NC Systems:**	**8 Hours**
2.1	Classification of CNC control systems	1 Hr
2.2	Open and Closed loop systems,	1 Hr
2.3	Types of CNC Machine Tools systems devices, e.g. encoders and interpolators	1 Hr
2.4	Features of CNC Systems,	1 Hr
2.5	Direct Numerical Control (DNC),	1 Hr
2.5	Standard Controllers and General Programming features available in CNC Systems,	2 Hr
2.6	Computer Process monitoring and Control. Adaptive control systems.	1 Hr
3	**Module-3- NC Part Programming**	**9 Hours**
3.1	Axis identification and coordinate systems	1 Hr

3.2	Structure of CNC part program, Programming codes	2 Hr
3.3	Programming for 2 and 3 axis control systems	1 Hr
3.4	Manual part programming for a turning center	1 Hr
3.5	,Programming using tool nose radius compensation	1 Hr
3.6	Tools offsets ,Do loops, sub routines and fixed cycles	1 Hr
3.7	Manual Programming for simple parts	2 hr
4	Module-4- **Computer aided part programming**;	**8 Hours**
4.1	Tools for computer aided part programming	2 Hr
4.2	Computer aided NC Programming in APT language	2 Hr
4.3	use of canned cycles,	1 Hr
4.4	Generation of NC Programmes through CAD/CAM systems	2 Hr
4.5	, Design and implementation of post processors.	1 Hr
5	**Module-5- Constructional Details of CNC Machines: Tooling of CNC Machines**	**12 Hours**
5.1	Machine structure ,Slide –ways ,Motion transmission elements	2 Hr
5.2	Swarf removal and safety considerations	1 Hr
5.3	Automatic tool changers and multiple pallet systems	1 Hr
5.4	Sensors and feedback devices in CNC machines	1 Hr
5.5	Constructional detail of CNC turning center	2 Hr
5.6	CNC machining center and Tooling requirements of CNC machines	1 Hr
5.8	Pre-set and qualified tools and Work and tool holding devices in CNC machines	2 Hr
5.10	Design considerations of CNC machines.	2 Hr