ANNEXURE 1

Regulation for B.Tech, 2019

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 = $\Sigma(C_i \times GP_i)/\Sigma C_i$, 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 = $\Sigma(C_i \times GP_i)/\Sigma C_i$, 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

B.TECH (2019 SCHEME)

CURRICULUM I TO VIII: B.Tech CHEMICAL 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 Ethics, 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 following table.

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.

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 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	HUT 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	HUT 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	CHT 201	CHEMISTRY FOR PROCESS ENGINEERING	3-1-0	4	4
C	CHT 203	CHEMICAL PROCESS PRINCIPLES	3-1-0	4	4
D	CHT 205	FLUID AND PARTICLE MECHANICS	3-1-0	4	4
E 1/2	EST 200	DESIGN & ENGINEERING	2-0-0	2	2
	HUT 200	PROFESSIONAL ETHICS	2-0-0	2	2
F	MCN 201	SUSTAINABLE ENGINEERING	2-0-0	2	--
S	CHL 201	CHEMICAL TECHNOLOGY & ENVIRONMENTAL ENGINEERING LAB	0-0-3	3	2
T	CHL 203	CHEMISTRY LAB FOR PROCESS ENGINEERING	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	CHT 202	CHEMICAL ENGINEERING THERMODYNAMICS	3-1-0	4	4
C	CHT 204	HEAT TRANSFER OPERATIONS	3-1-0	4	4
D	CHT 206	PARTICLE TECHNOLOGY	3-1-0	4	4
E 1/2	EST 200	DESIGN & ENGINEERING	2-0-0	2	2
	HUT 200	PROFESSIONAL ETHICS	2-0-0	2	2
F	MCN 202	CONSTITUTION OF INDIA	2-0-0	2	--
S	CHL 202	FLUID AND PARTICLE MECHANICS LAB	0-0-3	3	2
T	CHL 204	PARTICLE TECHNOLOGY LAB	0-0-3	3	2
R/M/H	VAC	REMEDIAL/MINOR/HONOURS 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	CHT 301	MASS TRANSFER OPERATIONS-I	3-1-0	4	4
B	CHT 303	ENVIRONMENTAL ENGINEERING	3-1-0	4	4
C	CHT 305	CHEMICAL REACTION ENGINEERING	3-1-0	4	4
D	CHT 307	INSTRUMENTATION AND PROCESS CONTROL	3-1-0	4	4
E 1/2	HUT 300	INDUSTRIAL ECONOMICS & FOREIGN TRADE	3-0-0	3	3
	HUT 310	MANAGEMENT FOR ENGINEERS	3-0-0	3	3
F	MCN 301	DISASTER MANAGEMENT	2-0-0	2	--
S	CHL 331	HEAT TRANSFER OPERATIONS LAB	0-0-3	3	2
T	CHL 333	PROCESS CONTROL LAB	0-0-3	3	2
R/M/H	VAC	REMEDIAL/MINOR/HONOURS 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	CHT 302	MASS TRANSFER OPERATIONS-II	3-1-0	4	4
B	CHT 304	TRANSPORT PHENOMENA	3-1-0	4	4
C	CHT 306	CHEMICAL TECHNOLOGY	3-1-0	4	4
D	CHT XXX	PROGRAM ELECTIVE I	2-1-0	3	3
E 1/2	HUT 300	INDUSTRIAL ECONOMICS & FOREIGN TRADE	3-0-0	3	3
	HUT 310	MANAGEMENT FOR ENGINEERS	3-0-0	3	3
F	CHT 308	COMPREHENSIVE COURSE WORK	1-0-0	1	1
S	CHL 332	MASS TRANSFER OPERATIONS LAB	0-0-3	3	2
T	CHL 334	CHEMICAL REACTION ENGINEERING LAB	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	CHT312	BIOCHEMICAL ENGINEERING	2-1-0	3	3
	CHT322	ENERGY ENGINEERING	2-1-0		
	CHT332	NUMERICAL METHODS FOR PROCESS ENGINEERS	2-1-0		
	CHT342	MATERIAL SCIENCE AND ENGINEERING	2-1-0		
	CHT352	OPERATIONS RESEARCH	2-1-0		
	CHT362	PROCESS INSTRUMENTATION	2-1-0		
	CHT372	CATALYST SCIENCE AND CATALYTIC PROCESSES	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 3 to 5 PM and Wednesdays from 2 to 4 PM). If a student does not opt for minor/honours 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 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	CHT 401	CHEMICAL PROCESS EQUIPMENT DESIGN I	2-1-0	3	3
B	CHT XXX	PROGRAM ELECTIVE II	2-1-0	3	3
C	CHT XXX	OPEN ELECTIVE	2-1-0	3	3
D	MCN 401	INDUSTRIAL SAFETY ENGINEERING	2-1-0	3	---
S	CHL 411	PROCESS SIMULATION LAB	0-0-3	3	2
T	CHQ 413	SEMINAR	0-0-3	3	2
U	CHD 415	PROJECT PHASE I	0-0-6	6	2
R/M/H	VAC	REMEDIAL/MINOR/HONOURS COURSE	3-1-0	4*	4
TOTAL				**24/28**	**15/19**

PROGRAM ELECTIVE II

SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
B	CHT413	FOOD PROCESSING AND TECHNOLOGY	2-1-0	3	3
	CHT423	OIL AND NATURAL GAS ENGINEERING	2-1-0		
	CHT433	PROCESS MODELLING AND SIMULATION	2-1-0		
	CHT443	CORROSION ENGINEERING	2-1-0		
	CHT453	PROJECT ENGINEERING	2-1-0		
	CHT463	INTRODUCTION TO DATA ANALYSIS	2-1-0		
	CHT473	FLUIDIZATION ENGINEERING	2-1-0		

OPEN ELECTIVE (OE)

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 CHEMICAL ENGINEERING for students of other undergraduate branches offered in the college under KTU**.

SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
C	CHT415	ENERGY TECHNOLOGY AND ENERGY MANAGEMENT	2-1-0	3	3
	CHT 425	PETROLEUM RESOURCES AND PETROCHEMICALS	2-1-0		
	CHT 435	PROCESS SAFETY ENGINEERING	2-1-0		
	CHT 445	PIPING AND PIPELINE DESIGN FOR PROCESS INDUSTRIES	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 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 faculty members comprising Academic coordinator for that program, seminar coordinator and seminar guide 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 Chemical 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	CHT 402	CHEMICAL PROCESS EQUIPMENT DESIGN II	2-1-0	3	3
B	CHT XXX	PROGRAM ELECTIVE III	2-1-0	3	3
C	CHT XXX	PROGRAM ELECTIVE IV	2-1-0	3	3
D	CHT XXX	PROGRAM ELECTIVE V	2-1-0	3	3
T	CHT 404	COMPREHENSIVE COURSE VIVA	1-0-0	1	1
U	CHD 416	PROJECT PHASE II	0-0-12	12	4
R/M/H	VAC	REMEDIAL/MINOR/HONOURS COURSE	3-1-0	4*	4
TOTAL				**25/29**	**17/21**

PROGRAM ELECTIVE III

SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
B	CHT414	AIR POLLUTION MONITORING & CONTROL	2-1-0	3	3
	CHT424	PETROLEUM REFINERY ENGINEERING	2-1-0		
	CHT434	COMPUTATIONAL FLUID DYNAMICS	2-1-0		
	CHT444	POLYMER TECHNOLOGY	2-1-0		
	CHT454	PROCESS UTILITY AND PIPING ENGINEERING	2-1-0		
	CHT464	DRUGS AND PHARMACEUTICALS TECHNOLOGY	2-1-0		
	CHT474	ELECTROCHEMICAL ENGINEERING	2-1-0		

PROGRAM ELECTIVE IV

SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
C	CHT416	ECONOMICS & MANAGEMENT OF CHEMICAL INDUSTRIES	2-1-0	3	3
	CHT426	PETROCHEMICALS AND FERTILIZERS	2-1-0		
	CHT436	MATHEMATICAL METHODS IN PROCESS ENGINEERING	2-1-0		
	CHT446	COMPOSITE MATERIALS	2-1-0		
	CHT456	CERAMIC TECHNOLOGY	2-1-0		
	CHT466	TOTAL QUALITY MANAGEMENT	2-1-0		
	CHT476	ENZYME ENGINEERING	2-1-0		

PROGRAM ELECTIVE V

SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
D	CHT418	SOLID WASTE MANAGEMENT	2-1-0	3	3
	CHT428	NONCONVENTIONAL PETROLEUM RESOURCES	2-1-0		
	CHT438	PROCESS OPTIMIZATION	2-1-0		
	CHT448	NANOMATERIALS AND NANOTECHNOLOGY	2-1-0		
	CHT458	SAFETY ENGINEERING OF PROCESS PLANTS	2-1-0		
	CHT468	NOVEL SEPARATION TECHNIQUES	2-1-0		
	CHT478	FUEL CELL TECHNOLOGY	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/honours 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 core subjects studied from third to eighth 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

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

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).

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 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 CHEMICAL ENGINEERING** 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	CHT251	INTRODUCTION TO CHEMICAL ENGINEERING	4	4	CHT251	INTRODUCTION TO CHEMICAL ENGINEERING	4	4	CHT251	INTRODUCTION TO CHEMICAL ENGINEERING	4	4
S4	CHT 252	SAFETY ENGINEERING OF PROCESS PLANTS	4	4	CHT 254	FUNDAMENTALS OF OIL AND NATURAL GAS ENGINEERING	4	4	CHT 256	MATERIAL SCIENCE AND ENGINEERING	4	4
S5	CHT 351	OCCUPATIONAL HEALTH AND INDUSTRIAL HYGIENE	4	4	CHT 353	PETROLEUM REFINERY ENGINEERING	4	4	CHT 355	POLYMER TECHNOLOGY	4	4
S6	CHT 352	HAZARD AND RISK ASSESSMENT	4	4	CHT 354	PETROCHEMICAL TECHNOLOGY	4	4	CHT 356	NANO MATERIALS AND NANO TECHNOLOGY	4	4
S7	CHD 451	MINI PROJECT	4	4	CHD 451	MINI PROJECT	4	4	CHD 451	MINI PROJECT	4	4
S8	CHD 452	MINI PROJECT	4	4	CHD 452	MINI PROJECT	4	4	CHD 452	MINI PROJECT	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 CHEMICAL 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	CHT272	COMPUTATIONAL METHODS IN CHEMICAL ENGINEERING	4	4	CHT 274	INSTRUMENTAL METHODS FOR ENVIRONMENTAL ENGINEERING	4	4	CHT 276	MODERN METHODS OF INSTRUMENTATION	4	4
S5	CHT373	ADVANCED HEAT TRANSFER	4	4	CHT 375	PHYSICO CHEMICAL METHODS IN ENVIRONMENTAL ENGINEERING	4	4	CHT 377	SOFT COMPUTING TECHNIQUES	4	4
S6	CHT374	CHEMICAL REACTION ENGINEERING II	4	4	CHT 376	ADVANCED WASTEWATER TREATMENT TECHNIQUES	4	4	CHT 378	MODERN CONTROL THEORY	4	4
S7	CHT475	PROCESS INTEGRATION	4	4	CHT 477	PROCESS DESIGN FOR WASTEWATER TREATMENT	4	4	CHT 479	ADVANCED PROCESS CONTROL	4	4
S8	CHD476	MINI PROJECT	4	4	CHD 476	MINI PROJECT	4		CHD 476	MINI PROJECT	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

batch mates 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.
- **Physical Activities & Sports**: Engage students in sports and physical activity to ensure healthy physical and mental growth.

SYLLUBUS & MODEL QUESTION PAPERS

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 $\frac{\partial^2 u}{\partial t^2} = c^2 \frac{\partial^2 u}{\partial x^2}$.
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 $\left(\frac{\partial z}{\partial x}\right)^2 + \left(\frac{\partial z}{\partial y}\right)^2 = \left(\frac{\partial z}{\partial r}\right)^2 + \frac{1}{r^2}\left(\frac{\partial z}{\partial \theta}\right)^2$.

(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, 10th edition, 2015.
2. Erwin Kreyszig, Advanced Engineering Mathematics, 10thEdition, John Wiley & Sons, 2016.

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 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 $7\times10^{4.}$ 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

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°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 ^1H 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

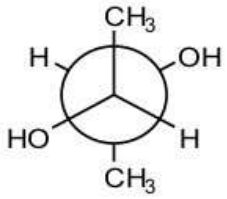
Max. Marks: 100 Duration: 3 Hours

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	^{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).	**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 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

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:

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

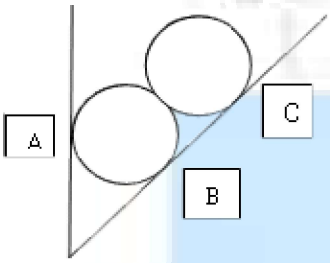
3. While you are riding your bike, you turn a corner following a circular arc. Illustrate the forces that act on your bike to keep you along the circular path ?

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 distributed 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.

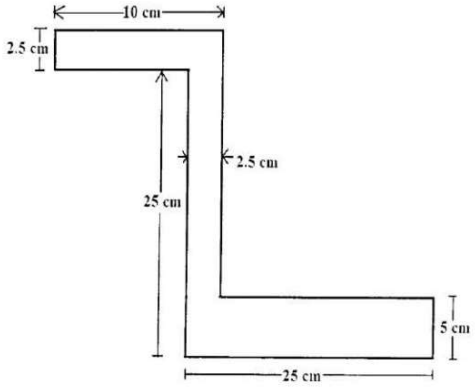


Course outcome identifier	Description of course outcome	Learning level assessed	Marks allocated
CO 3	To apply the conditions of equilibrium to various practical problems involving different force system.	Applying – (Sketch the free body diagram that represent equilibrium state of the body)	4
CO 4	To 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 given 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 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. 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

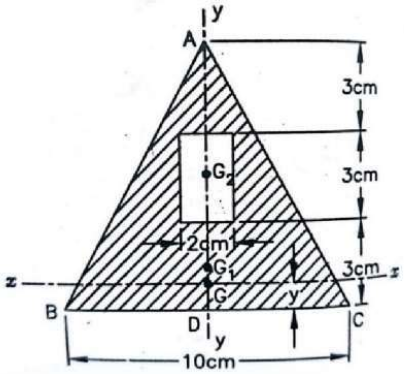
3. Determine the centroid of the given section



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.

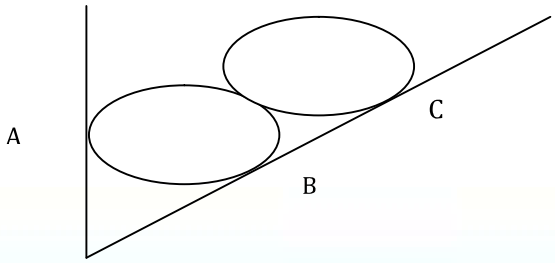
10. Highlight the principles of mechanics applied in the evaluation of elastic collusion of rigid bodies.

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)

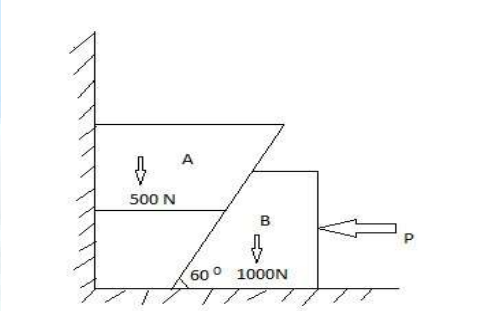


12. A string tied to a wall is made to pass over a pulley placed 2m away from it. A weight P is attached to the string such that the string stretches by 2m from the support on the wall to the location of attachment of weight. Determine the force P required to maintain 200 kg body in position for $\theta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

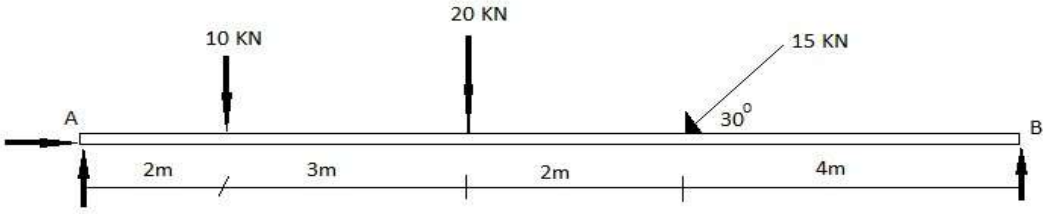
Module – 2

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)

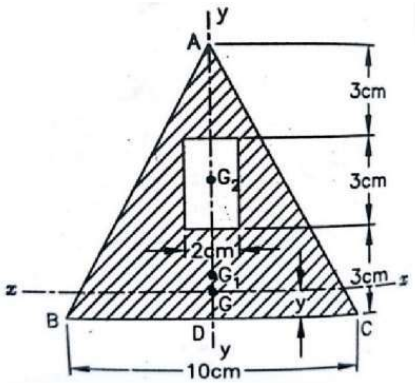


14. A beam is hinged at A and roller supported at B. It is acted upon by loads as shown below. Find the reactions at A & B. (14 marks)

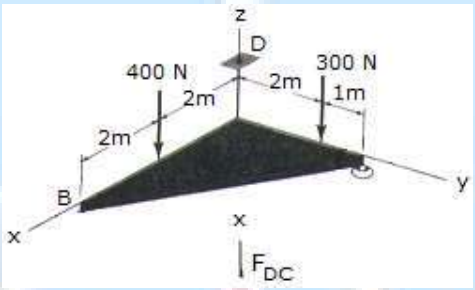


Module – 3

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 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° to HP and 45° to VP. Draw the projections of the solid.

MODULE III

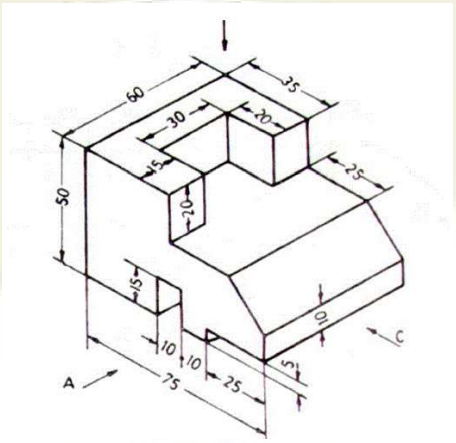
5. A triangular prism of base side 40mm and height 70mm is resting with its base on the ground and having an edge of the base perpendicular to VP. Section the solid such that the true shape of the section is a trapezium of parallel sides 30mm and 10mm. Draw the projections showing the true shape. Find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

Bloom's Category	**Basic Civil Engineering**			**Basic Mechanical Engineering**		
	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.

CO Questions

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.

CO Questions

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

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

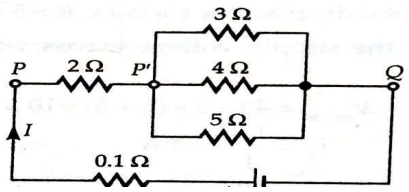
PART I

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.

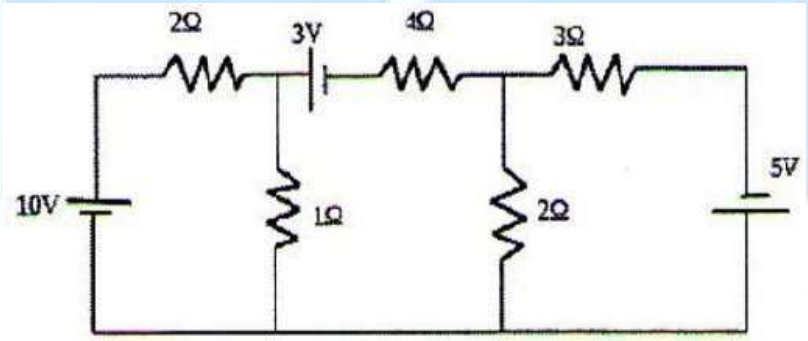
5. Compare electric and magnetic circuits. *(5x4=20)*

PART B

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

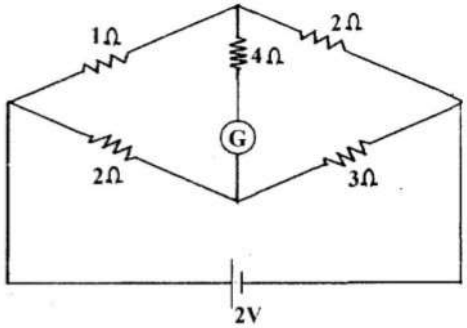
Module 1

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 $5\,\Omega$ 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 across each 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.

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

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 travels once 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 $y''' + 3y'' + 3y' + y = 30e^{-x}$ 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

APJ ABDUL KALAM
TECHNOLOGICAL
UNIVERSITY
KTU
KTU
2014

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. Read 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.

SEMESTER -3

MATHEMATICS – Third Semester B. Tech

(For all branches except Computer Science and Information Technology)

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
MAT201	PARTIAL DIFFERENTIAL EQUATIONS AND COMPLEX ANALYSIS	BASIC SCIENCE COURSE	3	1	0	4

Preamble: This course introduces basic ideas of partial differential equations which are widely used in the modelling and analysis of a wide range of physical phenomena and has got application across all branches of engineering. To understand the basic theory of functions of a complex variable, residue integration and conformal transformation.

Prerequisite: A basic course in partial differentiation and complex numbers.

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

CO 1	Understand the concept and the solution of partial differential equation.
CO 2	Analyse and solve one dimensional wave equation and heat equation.
CO 3	Understand complex functions, its continuity differentiability with the use of Cauchy-Riemann equations.
CO 4	Evaluate complex integrals using Cauchy's integral theorem and Cauchy's integral formula, understand the series expansion of analytic function
CO 5	Understand the series expansion of complex function about a singularity and Apply residue theorem to compute several kinds of real integrals.

Mapping of course outcomes with program outcomes

PO's	Broad area
PO 1	Engineering Knowledge
PO 2	Problem Analysis
PO 3	Design/Development of solutions
PO 4	Conduct investigations of complex problems
PO 5	Modern tool usage
PO 6	The Engineer and Society
PO 7	Environment and Sustainability
PO 8	Ethics
PO 9	Individual and team work

PO 10	Communication
PO 11	Project Management and Finance
PO 12	Life long learning

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				2		2
CO 2	3	3	3	3	2	1				2		2
CO 3	3	3	3	3	2	1				2		2
CO 4	3	3	3	3	2	1				2		2
CO 5	3	3	3	3	2	1				2		2

Assessment Pattern

Bloom's Category	Continuous Assessment Tests(%)		End Semester Examination(%)
	1	2	
Remember	10	10	10
Understand	30	30	30
Apply	30	30	30
Analyse	20	20	20
Evaluate	10	10	10
Create			

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. Form the partial differential equation given $z = xf(x) + ye^2$
2. What is the difference between complete integral and singular integral of a partial differential equation
3. Solve $3z = xp + yq$
4. Solve $(p^2 + q^2)y = qz$
5. Solve $u_x - 2u_t = u$ by the method of separation of variables

Course Outcome 2 (CO2):

1. Write any three assumptions in deriving one dimensional wave equations
2. Derive one Dimensional heat equation
3. Obtain a general solution for the one dimensional heat equation $\frac{\partial u}{\partial t} = c^2 \frac{\partial^2 u}{\partial t^2}$
4. A tightly stretched flexible string has it's ends fixed at $x = 0$and $x = l$. At $t = 0$, the string is given a shape defined by $f(x) = \mu x(l - x)$ where μ is a constant
5. Find the temperature $u(x, t)$ in a bar which is perfectly insulated laterally whose ends are kept at $0°C$ and whose initial temperature (in degree Celsius) is $f(x) = x(10 - x)$ given that it's length is 10 cm and specific heat is 0.056cal/gram deg

Course Outcome 3(CO3):

1. Separate the real and imaginary parts of $f(z) = \frac{1}{1+z}$
2. Check whether the function $f(z) = \frac{Re(z^2)}{|z|}$ is continuous at $z = 0$ given $f(0) = 0$
3. Determine a and b so that function $u = e^{-\pi x} cosay$ is harmonic. Find it's harmonic conjugate.
4. Find the fixed points of $w = \frac{i}{2z-1}$
5. Find the image of $|z| \leq \frac{1}{2}$, $-\frac{\pi}{8} < argz < \frac{\pi}{8}$under $w = z^2$

Course Outcome 4(CO4):

1. Find the value of $\int_C exp(z^2)dz$ where C is $|z| = 1$
2. Integrate the function $\int_C \frac{sinz}{z+4iz} dz$ where C is $|z - 4 - 2i| = 6.5$
3. Evaluate $\int_C \frac{e^z}{\left(z-\frac{\pi}{4}\right)^3} dz$ where C is $|z| = 1$
4. Find the Maclaurin series expansion of $f(z) = \frac{i}{1-z}$ and state the region of convergence.
5. Find the image of $|z| = 2$ under the mapping $w = z + \frac{1}{z}$

Course Outcome 5 (CO5):

1. Determine the singularity of $exp\left(\frac{1}{z}\right)$
2. Find the Laurent series of $\frac{1}{z^2(z-i)}$ about $z = i$
3. Find the residues of $f(z) = \frac{50z}{z^3 + 2z^2 - 7z + 4}$
4. Evaluate $\int_C tan2\pi z \, dz$ where C is $|z - 0.2| = 0.2$
5. Evaluate $\int_0^{2\pi} \frac{d\theta}{\sqrt{2} - cos\,\theta}$

Syllabus

Module 1 (Partial Differential Equations) (8 hours)

(Text 1-Relevant portions of sections 17.1, 17.2, 17.3, 17.4, 17.5, 17.7, 18.1, 18.2)

Partial differential equations, Formation of partial differential equations –elimination of arbitrary constants-elimination of arbitrary functions, Solutions of a partial differential equations, Equations solvable by direct integration, Linear equations of the first order-Lagrange's linear equation, Non-linear equations of the first order -Charpit's method, Solution of equation by method of separation of variables.

Module 2 (Applications of Partial Differential Equations) (10 hours)

(Text 1-Relevant portions of sections 18.3,18.4, 18.5)

One dimensional wave equation- vibrations of a stretched string, derivation, solution of the wave equation using method of separation of variables, D'Alembert's solution of the wave equation, One dimensional heat equation, derivation, solution of the heat equation

Module 3 (Complex Variable – Differentiation) (9 hours)

(Text 2: Relevant portions of sections13.3, 13.4, 17.1, 17.2 , 17.4)

Complex function, limit, continuity, derivative, analytic functions, Cauchy-Riemann equations, harmonic functions, finding harmonic conjugate, Conformal mappings- mappings $w = z^2,, w = e^z,$. Linear fractional transformation $w = \frac{1}{z}$, fixed points, Transformation $w = sinz$

(From sections 17.1, 17.2 and 17.4 only mappings $w = z^2,, w = e^z, w = \frac{1}{z}$, $w = sinz$ and problems based on these transformation need to be discussed)

Module 4 (Complex Variable – Integration) (9 hours)

(Text 2- Relevant topics from sections14.1, 14.2, 14.3, 14.4,15.4**)**

Complex integration, Line integrals in the complex plane, Basic properties, First evaluation method-indefinite integration and substitution of limit, second evaluation method-use of a representation of a path, Contour integrals, Cauchy integral theorem (without proof) on simply connected domain,Cauchy integral theorem (without proof) on multiply connected domain Cauchy Integral formula (without proof), Cauchy Integral formula for derivatives of an analytic function, Taylor's series and Maclaurin series.,

Module 5 (Complex Variable – Residue Integration) **(9 hours**)

(Text 2- Relevant topics from sections16.1, 16.2, 16.3, 16.4 **)**

Laurent's series(without proof), zeros of analytic functions, singularities, poles, removable singularities, essential singularities, Residues, Cauchy Residue theorem (without proof), Evaluation of definite integral using residue theorem, Residue integration of real integrals – integrals of rational functions of $cos\theta$ and $sin\theta$, integrals of improper integrals of the form

$\int_{-\infty}^{\infty} f(x)\,dx$ with no poles on the real axis. ($\int_{A}^{B} f(x)\,dx$ whose integrand become infinite at a point in the interval of integration is excluded from the syllabus),

Textbooks:

1. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 44th Edition, 2018.

2. Erwin Kreyszig, Advanced Engineering Mathematics, 10th Edition, John Wiley & Sons, 2016.

References:

1. Peter V. O'Neil, Advanced Engineering Mathematics, Cengage, 7th Edition, 2012

Assignments

Assignment: Assignment must include applications of the above theory in the concerned engineering branches

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Partial Differential Equations**	
1.1	Partial differential equations, Formation of partial differential equations –elimination of arbitrary constants-elimination of arbitrary functions, Solutions of a partial differential equations, Equations solvable by direct integration,	3
1.2	Linear equations of the first order- Lagrange's linear equation, Non-linear equations of the first order - Charpit's method	3
1.3	Boundary value problems, Method of separation of variables.	2
2	**Applications of Partial Differential Equations**	
2.1	One dimensional wave equation- vibrations of a stretched string, derivation,	1
2.2	Solution of wave equation using method of separation of variables, Fourier series solution of boundary value problems involving wave equation, D'Alembert's solution of the wave equation	4
2.3	One dimensional heat equation, derivation,	1
2.4	Solution of the heat equation, using method of separation of variables, Fourier series solutions of boundary value problems involving heat equation	4

3	**Complex Variable – Differentiation**	
3.1	Complex function, limit, continuity, derivative, analytic functions, Cauchy-Riemann equations,	4
3.2	harmonic functions, finding harmonic conjugate,	2
3.3	Conformal mappings- mappingsof $w = z^2, , w = e^z, w = \frac{1}{z}, w = sinz$.	3
4	**Complex Variable – Integration**	
4.1	Complex integration, Line integrals in the complex plane, Basic properties, First evaluation method, second evaluation method, use of representation of a path	4
4.2	Contour integrals, Cauchy integral theorem (**without proof**) on simply connected domain, on multiply connected domain(**without proof**) .Cauchy Integral formula (**without proof**),	2
4.3	Cauchy Integral formula for derivatives of an analytic function,	2
4.3	Taylor's series and Maclaurin series.	1
5	**Complex Variable – Residue Integration**	
5.1	Laurent's series(**without proof**)	2
5.2	zeros of analytic functions, singularities, poles, removable singularities, essential singularities, Residues,	2
5.3	Cauchy Residue theorem (**without proof**), Evaluation of definite integral using residue theorem	2
5.4	Residue integration of real integrals – integrals of rational functions of $cos\theta$and $sin\theta$, integrals of improper integrals of the form $\int_{-\infty}^{\infty} f(x)dx$with no poles on the real axis. ($\int_A^B f(x)dx$**whose integrand become infinite at a point in the interval of integration is excluded from the syllabus**),	3

Model Question Paper

(For all branches except Computer Science and Information Technology)

(2019 Scheme)

Reg No: Name:

APJ ABDULKALAM TECHNOLOGICAL UNIVERSITY

THIRD SEMESTER B.TECH. DEGREE EXAMINATION

(MONTH & YEAR)

Course Code:

Course Name: PARTIAL DIFFERENTIAL EQUATIONS AND COMPLEX ANALYSIS

MAX.MARKS: 100 DURATION: 3 Hours

PART A

Answer all questions, each carries 3 marks.

1. Derive a partial differential equation from the relation $z = f(x + at) + g(x - at)$
2. Solve $\frac{\partial^2 z}{\partial x \partial y} = x^2 y$
3. State any three assumptions in deriving the one dimensional wave equation
4. What are the possible solutions of one-dimensional heat equation?
5. If $f(z) = u + iv$ is analytic, then show that u *and* v are harmonic functions.
6. Check whether $f(z) = \bar{z}$ is analytic or not.
7. Evaluate $\int_c tan\, z\, dz$ where c is the unit circle.
8. Find the Taylor's series of $f(z) = \frac{1}{z}$ about $z = 2$.
9. What type of singularity have the function $f(z) = \frac{1}{\cos z - \sin z}$
10. Find the residue of $\frac{e^z}{z^3}$ at its pole.

PART B

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

Module-I

11. (a) Solve $x(y - z)p + y(z - x)q = z(x - y)$
    (b) Use Charpit's methods to solve $q + xp = p^2$
12. (a) Find the differential equation of all spheres of fixed radius having their centers in the xy-plane.

(b) Using the method of separation of variables, solve $\frac{\partial u}{\partial x} = 2\frac{\partial u}{\partial t} + u$, where $u(x,0) = 6e^{-3x}$.

Module – II

13. (a) Derive the solution of one dimensional wave equation $\frac{\partial^2 u}{\partial t^2} = c^2 \frac{\partial^2 u}{\partial x^2}$ with zero boundary conditions and with initial conditions $u(x,0) = f(x)$ and $\left(\frac{\partial u}{\partial t}\right)_{t=0} = 0$.

(b) A homogeneous rod of conducting material of length 100 cm has its ends kept at zero temperature and the temperature initially is $u(x,0) = \begin{cases} x, 0 \le x \le 50 \\ 100 - x, 50 \le x \le 100 \end{cases}$. Find the temperature $u(x,t)$ at any time.

14. (a) A tightly stretched string of length l with fixed ends is initially in equilibrium position. It is set vibrating by giving each point a velocity $v_0 \sin^3\left(\pi x/l\right)$. Find the displacement of the string at any time.

(b) An insulated rod of length l has its ends A and B are maintained at 0^0c and 100^0C respectively under steady state condition prevails. If the temperature at B is suddenly reduced to 0^0c and maintained at 0^0c, Find the temperature at a distance x from A at time t.

Module-III

15. (a) Show that $f(z) = e^z$ is analytic for all z. Find its derivative.

(b) Find the image of $|z - 2i| = 2$ under the transformation $w = \frac{1}{z}$

16. (a) Prove that the function $u(x,y) = x^3 - 3xy^2 - 5y$ is harmonic everywhere. Find its harmonic conjugate.

(b) Find the image of the infinite stripe $0 \le y \le \pi$ under the transformation $w = e^z$

Module-IV

17. (a) Evaluate $\int_0^{2+i} (\bar{z})^2 \, dz$, along the real axis to 2 and then vertically to $2 + i$

(b) Using Cauchy's integral formula evaluate $\int_c \frac{5z+7}{z^2+2z-3} dz$, where c is $|z - 2| = 2$

18. (a) Evaluate $\int_c \frac{\sin^2 z}{\left(z - \frac{\pi}{6}\right)^3} dz$, where C is $|z| = 1$.

(b) Expand $\frac{1}{(z-1)(z-2)}$ in the region $|z| < 1$

Module- V

19. (a) Expand $f(z) = \frac{z^2-1}{z^2-5z+6}$ in $2 < |z| < 3$ as a Laurent's series.

(b) Using contour integration evaluate $\int_0^{2\pi} \frac{d\theta}{2+\cos\theta}$

20. (a) Use residue theorem to evaluate $\int_c \frac{\cos h\, \pi z}{z^2+4} dz$ where are C is $|z| = 3$.

(b) Apply calculus of residues to evaluate $\int_{-\infty}^{\infty} \frac{1}{(x^2+1)^3} dx$.

SEMESTER -3

CHT 201	CHEMISTRY FOR PROCESS ENGINEERING	CATEGORY	L	T	P	CREDIT
		BSC	3	1	0	4

Preamble: Out of five modules, two are devoted to Analytical Chemistry which includes the principles, instrumentation and applications of most modern analytical techniques. By understanding the working principles of these significant tools they can easily perform analytical experiments. Significant topics from Physical chemistry which are very much relevant to process engineering students are introduced in the remaining modules. After the completion of this course, students will be able to describe adsorption isotherms, photochemistry of chemical processes, chemical kinetics, distribution law and properties of colloids. They also attain the skill to solve various physical chemistry problems.

Prerequisite: Basic knowledge in Engineering Chemistry

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

CO 1	Describe the principles, instrumentation and applications of advanced electrochemical analytical tools.
CO 2	Explain the working principles, instrumentation and applications of atomic and molecular spectroscopic techniques and Electron microscopy.
CO 3	Illustrate distribution law and apply the knowledge in solvent extraction and describe the kinetics of different chemical processes.
CO 4	Interpret different adsorption isotherms and familiarize colloids, emulsion and surfactants.
CO 5	Explain the basic concepts of nuclear chemistry and photochemical process and solve decay kinetic 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	PO 10	PO 11	PO 12
CO 1	3	2	3		3		2		2			2
CO 2	3	3	2		3		2					
CO 3	3	3	3	2			2		2			2
CO 4	3	3	1	3			2					2
CO 5	3	3	1	2		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. Describe the principle and instrumentation of amperometric titration.

2. Half wave potential in a polarogram is the important characteristic of a metal ion. Justify the statement

3. Construct a biosensor for the estimation of blood glucose. Illustrate the principle.

Course Outcome 2 (CO2)

1. Explain the principle, instrumentation and applications of Mass spectrometry.

2. XRD is a useful technique for estimating crystal parameters. Explain.

3. Describe the working principle of Scanning Electron Microscopy.

Course Outcome 3(CO3):

1. Derive Nernst distribution law.

2. The distribution co-efficient of isobutytric acid between ether and water is 3 at 25^{o}C. What will be the amount of isobutyric acid removed if 4g of isobutyric acid in 100ml of water is extracted with 100ml of ether at 25^{o}C?

3. Derive the rate expression for the second order reaction 2A$\rightarrow$P

Course Outcome 4 (CO4):

1. Derive Langmuir adsorption isotherm.

2. Define Gibbs surface excess. Using Gibbs isotherm explain the change of surface tension of water in the presence of NaCl and Soap.

3. Describe the mechanism of action of various surfactants.

Course Outcome 5 (CO5):

1. Describe the factors affecting nuclear stability.

2. Derive the kinetic rate expression for the photochemical combination of hydrogen and chlorine.

3. An archaeological specimen when subjected to carbon dating showed β-ray activity 10. A similar sample of fresh material displayed activity 21. Calculate the age of the archaeological sample. The half life of C-14 is 5730 years.

Model Question paper

Reg No:_____

Name :_____

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

Course Code: CHT 201

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

CHEMISTRY FOR PROCESS ENGINEERING

(2019-Scheme)

PART A

(Answer all questions, each question carries 3 marks)

1. What is DME? What are the advantages and disadvantages of DME?
2. Describe half wave potential in polarography. What is its significance?
3. Give the principle of Auger electron spectroscopy.
4. Bragg's law is the backbone of this analytical tool. Identify the technique and explain the principle.
5. The distribution co-efficient of isobutytric acid between ether and water is 3 at 25^{o}C. What will be the amount of isobutyric acid removed if 4g of isobutyric acid in 100ml of water is extracted with 100ml of ether at 25^{o}C?
6. Derive the rate expression for primary salt effect.
7. What are the limitations of Freundlich adsorption isotherm?
8. Describe the terms critical micelle concentration and micellar aggregation number.
9. Nuclear fission can be beautifully portrayed with the help of liquid drop model. Comment.
10. Differentiate between fluorescence and phosphorescence.

PART B

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

Module I

11. a) Suppose you are provided with a zinc sulphate solution of approximate concentration 10^{-10}M. Which analytical tool will you choose for the estimation of this solution? Give the working principle of this technique. (7M)

    b) Calculate the amount of copper deposited from copper sulphate solution if one passes 10 A of current for 20 minutes (3M)

    c) Explain various currents involved in Polarography (4M)

12. a) How potentiometry is useful for precipitation titration? Explain with an example (7M)

    b) Give the principle and any two applications of amperometric titration (7M)

Module II

13. a) A salt crystallises in the orthorhombic system with the unit cell dimensions are a=542pm, b=917 pm and c=645 pm. Calculate the diffraction angles for first order X-ray reflection from (100), (010) and (111) planes using X-ray with λ= 154 pm (8M)

    b) Describe the principle of Scanning Electron Microscopy (6M)

14. a) Give the principle, instrumentation and applications of XPS. (7M)

    b) Draw a schematic diagram of mass spectrometer and label the component. Explain the working principle of mass spectrometry (7M)

Module -III

15. a) Define critical solution temperature? Explain phenol-water system and nicotine-water system with diagrams (8M)

    b) Derive the integrated rate expression for third order reaction of the type $3A \rightarrow P$ (6M)

16. a) Describe four methods for the determination of order of reaction (8M)

    b) In the distribution of succinic acid between ether and water at 15ºC, 20 ml of the ethereal layer contains 0.092 g of the acid. Find out the weight of the acid present in 50 ml of the aqueous solution in equilibrium with it if the distribution coefficient for succinic acid between water and ether is 5.2. (6M)

Module -IV

17. a) Derive Gibbs adsorption isotherm and explain surface excess (10M)

    b) Define zeta potential? How it is determined? (4M)

18. a) Give the classification of surfactants. (8M)

    b) Calculate the surface area per gram of silica gel if it adsorbs 130cm^3/g of nitrogen at 0^0C and at 1atm pressure (6M)

Module -V

19. a) Derive the integrated rate expression for the disintegration of radioactive substance and calculate half life of disintegration (7M)

    b) Illustrate the principle of Neutron activation analysis. Write any three applications of it. (7M)

20. a) Calculate the age of an arheological sample showing an beta ray activity 30% when compared to the living sample. The half life of ^{14}C is 5760 years. (7M)

    b) Derive the kinetic rate expression for the photochemical reaction between H_2 and Cl_2 ? (7M)

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Syllabus

Module 1: Electroanalytical techniques: Conductometric titrations. Potentiometry, Polarography Dropping mercury electrode (DME), Anodic stripping voltammetry. Amperometry, Coulometric titrations, Electrogravimetry. Electrochemical sensors.

Module 2: Spectroscopic and Surface Analytical Techniques- Mass spectrometry, Atomic Absorption spectroscopy (AAS), Atomic Emission spectroscopy (AES), X–Ray photoelectron spectroscopy (XPS), auger electron spectroscopy, X-Ray Diffraction Studies (XRD), Scanning electron microscopy (SEM), scanning tunneling electron microscopy (STM) and atomic force microscopy (AFM).

Module 3: Phase equilibrium and Chemical Kinetics- Nernst distribution law and applications. Solvent extraction, Parke's process. Solubility of partially miscible liquids. Critical solution temperature. Order and molecularity of reactions- Rate expression for First, second, third and zero order reactions, half lives, determining order of reactions- Primary Salt effect.

Module 4: Adsorption and Surface Chemistry –Adsorption, Adsorption Isotherms – Langmuir, Freundlich and BET, Gibbs adsorption isotherm – derivation. Colloids –,

Protective colloids, Gold number, Zeta potential, Emulsion, Micelles- Critical micelle concentration, Micellar catalysis. Surfactants.

Module 5: Nuclear and Photochemistry -Radioactivity, Nuclear stability,First order decay expression, transient & secular equilibria. Nuclear reaction cross-section. Liquid drop model, nuclear fission, Neutron activation analysis. Medical isotopes, Tracers, dating techniques, Consequences of light absorption- Jabalonski diagram. Laws of photochemistry, Kinetics of Hydrogen-Chlorine reaction. Chemiluminescence and bioluminescence

Text Books

1. B. R. Puri, L.R. Sharma, M.S. Pathania, Principles of Physical Chemistry, Vishal Publishing Co., 2013.
2. R. L. Madan and G. D. Tuli *Physical Chemistry,* published by S. Chand Publishing, Edition 2016
3. A. Bahl, B. S Bhal and G D Tuli, Essentials of Physical Chemistry, S. Chand Publishing, Edition 2010

Reference Books

1. D.A. Skoog, D.M. West, F.J. Holler, S.R. Crouch, Fundamentals of Analytical Chemistry, 8th edition, Saunders College Pub., 2007.

2. H.H. Willard, L.L. Merritt Jr. J.A. Dean, F. A. Settle Jr., 7th ed., Wadsworth Publishing Co., 1988.

3. G.R. Chatwal, S.K. Anand, Instrumental Methods of Chemical Analysis, 5th edition, Himalaya, 2007.

4. W. Atkins, Physical Chemistry, OxofordUniversity Press, 10th edn., 2014

5. Thomas Engel, Philip Reid, Physical Chemistry, Pearson Education Publications 2018

6. D. Harvey, Modern analytical chemistry, McGraw-Hill, Inc. 2000.

7. J. A. C. Broekaert, Analytical Atomic Spectrometry with Flames and Plasmas, Wiley-VCH, 2002.

8. P. Atkins, J. de Paula, Elements of Physical Chemistry, 5th edition, Oxford University Press, 2009.

9. P. J. Gellings, H. J. M. Bouwmeester (editors), The CRC handbook of solid state electrochemistry, CRC Press, Inc., 1996.

10. J. Wang, Analytical Electrochemistry, 2nd edition, Wiley-VCH, 2000.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Electro-analytical chemistry (9 hours)**	
1.1	Conductometry- principle and applications (acid-base titrations and precipitation titrations). Potentiometry – Principle, determination of equivalence points for acid–base, complexation, redox, and precipitation titrations.	3
1.2	Polarography -Residual current, migration current, diffusion current (Ilkovic equation) and limiting current. Half wave potential. Dropping mercury electrode (DME). Applications of polarogarphy.	2
1.3	Anodic stripping voltammetry. Amperometry. Coulometric titrations. Electrogravimetry. Electrochemical sensors (Biosensors for glucose, ethanol and urea, gas sensors for Oxygen and CO_2)	4
2	**Spectroscopic and Surface Analytical Techniques (9 hours)**	
2.1	Principle, instrumentation and applications of Mass spectrometry, Atomic Absorption Spectroscopy (AAS) , Atomic Emission spectroscopy (AES)	3
2.2	X–Ray photoelectron spectroscopy (XPS), Auger electron spectroscopy, X-Ray Diffraction Studies (XRD).	4
2.3	Scanning electron microscopy (SEM), scanning tunneling electron microscopy (STM) and atomic force microscopy (AFM).	2
3	**Phase equilibrium and Chemical Kinetics (9 hours)**	
3.1	Nernst distribution law (thermodynamic derivation), association and dissociation of solute, chemical combination of solute with solvent. Application of Nernst distribution law, principles of solvent extraction, Parke's process. Numerical problems of distribution law.	3
3.2	Solubility of partially miscible liquids. Critical solution temperature. Phenol – water, triethylamine – water and nicotine – water systems.	2
3.3	Order and molecularity of reactions- Rate expression for First, second, third and zero order reactions – Half lives (Derivation and numerical problems)- Methods for determining order of reactions- Primary Salt effect-Derivation	4
4	**Adsorption and Surface Chemistry (9 hours)**	
4.1	Adsorption- Types, Adsorption Isotherms – Langmuir, Freundlich	3

	and BET equations (no derivation for BET). Determination of surface area using BET equation. Gibbs adsorption isotherm – derivation, Gibbs surface excess.	
4.2	Colloids – classification, preparation and purification, Protective colloids, Gold number, stability of colloids, Zeta potential- factors affecting, determination of zeta potential.	2
4.3	Emulsion – properties and applications, Hydrophilic and Lipophilic balances (HLB), Micelles- Shape and Structure, Micellar aggregation Number, Critical micelle concentration (CMC) and factors affecting CMC, Micellar catalysis. Surfactants - types and uses.	4
5	**Nuclear and Photochemistry (9 hours)**	
5.1	Radioactivity, types of radioactive decays. Nuclear stability-n/p ratio, binding energy and Magic numbers. First order decay expression, half life- numerical problems. Consecutive decays-transient & secular equilibria. Nuclear reaction cross-section. Liquid drop model of nuclear fission and fissionability parameters.	4
5.2	Neutron activation analysis. Medical isotopes and treatment. Tracers, dating techniques, numerical problems.	2
5.3	Consequences of light absorption-Radiative and Non radiative transitions, Jabalonski diagram- fluorescence and phosphorescence. Laws of photochemistry, Quantum yield. Kinetics of Hydrogen-Chlorine reaction. Chemiluminescence, bioluminescence in fire fly.	3

CHT 203	CHEMICAL PROCESS PRINCIPLES	CATEGORY	L	T	P	CREDIT
		PCC	3	1	0	4

Preamble: Objective of this course is to establish fundamental principles of Chemical Engineering in a simple and up-front manner and to provide the broad background for applying these principles to industrial and theoretical problems.This course introduces students to basic concepts of composition calculations practiced in chemical processes, equations of states, material and energy balances etc. which are at the fundamental and core areas of Chemical Engineering course.

Prerequisite: CYT 100: Engineering Chemistry, MAT 101: Linear Algebra & Calculus

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

CO1	Distinguish and summarize various unit operations & unit processes.
CO2	Translate physical quantities and empirical equations from one set of units to another quickly and accurately.
CO3	Estimate chemical composition and other physical quantitiessuch as density, flow rate, pressure and temperature.
CO4	Apply ideal and real gas equations of state to establish fundamental properties of fluids.
CO5	Define various terminologies related to humidification and utilize the humidity chart to determine the properties of air-water vapour system.
CO6	Develop and solve basic material & energy balance equations for the unit operations and unit processes employed in process industries.

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	…	…	…	…	…	…	…	…	…	…
CO 3	3	3	…	…	…	…	…	…	…	…	…	…
CO 4	3	3	…	…	…	…	…	…	…	…	…	…
CO 5	3	3	…	…	…	…	…	…	…	…	…	…
CO 6	3	3	…	…	…	…	…	…	…	…	…	…

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
Analyze			
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): Distinguish and summarize various unit operations & unit processes.

1. Differentiate between Unit Operations and Unit Processes. Give two examples for each. Write the classification of unit operations.
2. Name the unit operation that utilizes the principle of separation of components based on the relative volatility. Differentiate the same with evaporation.
3. Define unit operation. Explain any one unit operation dealing with solid-liquid separations.

Course Outcome 2 (CO2): Translate physical quantities and empirical equations from one set of units to another quickly and accurately.

1. Stefan Boltzmann constant associated with radiation heat transfer is represented in FPS system as 0.171×10^{-8} Btu/hr.(ft)^2.(^{o}R)^4. Calculate its value in SI system.
2. A pressure gauge on a process tower indicates a vacuum of 3.53 inch Hg. The barometer reads 29.31 inch Hg. Calculate the absolute pressure in the tower in mm Hg.
3. The flow rate of water through a pipe is reported as 25 cubic feet per minute. Taking density of water as 1 g/cm^3, calculate the mass flow rate in kg/s.

Course Outcome 3(CO3): Estimate chemical composition and other physical quantities such as density, flow rate, pressure and temperature.

1. A mixture of SO_2 and O_2 is at 200 kPa. Average molecular weight of mixture is 44.8. Find the partial pressure of O_2.
2. Natural gas has the following composition by volume percent. CH_4 – 83.5%; C_2H_6 – 12.5% and rest Nitrogen. Calculate:
    a. Composition in mole %
    b. Composition in Wt%
    c. Average molecular weight.
3. The molecular formula of an organic compound is $C_{10}H_7Br$. Find weight percentage of carbon, hydrogen and bromine in the solid.

Course Outcome 4 (CO4): Apply ideal and real gas equations of state to establish fundamental properties of fluids.

1. Calculate the pressure developed by one kmol of NH_3 gas contained in a vessel of 0.6m^3 capacity at a constant temperature of 473 K using Van der Waals equation. Given that a = 0.4233 Nm^4/mol^2 and b = 3.73×10^{-5} m^3/mol.
2. Define equation of state. List any two equations of state.
3. Estimate the molar volume of CO_2 at 500 K and 100 bar usingthe Van der Waals equation. Given that a = 0.364 Nm^4/mol^2 and b = 4.267×10^{-5} m^3/mol.

Course Outcome 5 (CO5): Define various terminologies related to humidification and utilize the humidity chart to determine the properties of air-water vapour system.

1. Define the following terms: (i) Dry bulb temperature, (ii) Wet bulb temperature, (iii) Absolute humidity and (iv) Relative saturation.

2. The dry bulb temperature and dew point of an air sample are 333 K and 313 K respectively. Determine the following using psychrometric chart:(i) The absolute humidity, (ii)percentage humidity, (iii)Humid volume and (iv) Enthalpy of wet air.
3. The dry bulb and wet bulb temperature of an air sample are 328 K and 308 K respectively at 101.3 kPa. Determine the following using psychrometric chart: (i)The absolute humidity, (ii)Molal humidity, (iii)Percent saturation, (iv)Wet bulb temperature and (v) Humid volume.

Course Outcome 6 (CO6): Develop and solve basic material balance equations for the unit operations and unit processes employed in process industries.

1. 1000 kg of mixed acid of composition 40% H_2SO_4, 45% HNO_3 and 15% H_2O is to be produced by strengthening waste acid of composition 30% H_2SO_4, 36% HNO_3 and 34% H_2O by weight. Concentrated sulphuric acid of strength 95% and concentrated nitric acid containing 80% acid are available for this purpose. Calculate in kilograms, the amount of spent acid and concentrated acid to be mixed together.
2. A fuel oil containing 88.2% Carbon and 11.8% Hydrogen (by weight) is burnt with 20% excess air. 95% of the carbon is burnt to carbon dioxide and the rest to carbon monoxide. All the hydrogen is converted to water. Determine the Orsat analysis of the flue gas.
3. An evaporator is fed continuously with 2500 kg/hr of a solution which contains 10% NaCl, 10% NaOH and 80% H_2O. During evaporation, H_2O is removed from the solution and NaCl precipitates as crystals which is settled and removed. The concentrated liquor leaving the evaporator contains 50% NaOH, 2% NaCl and 48% H_2O. Calculate

   (i)Weight of salt precipitated per hour.

   (ii) Weight of concentrated liquor leaving per hour.

Course Outcome 7 (CO7): Develop and solve energy balance equations for various physical and chemical processes.

1. 10 kmol of zinc are to be heated from 0 ^oC to 1000 ^oC. It melts at 419 ^oC and boils at 907^oC. Determine the heat required for the process. Use Trouton's rule to estimate the latent heat of melting.

   Data:

   C_{pm} of solid Zn = 0.105 kcal/kg ^oC

C_{pm} of molten Zn = 0.109 kcal/kg ^{o}C

C_{pm} of vapor Zn = 4.97 kcal/kmol

ΔH_{vap} = 26900 kcal/kmol

2. Calculate the theoretical flame temperature of a gaseous fuel containing 20% CO, and 80% N_2 when burnt with 100% excess air, both air and gas initially being at 25^{o}C. Heat of combustion of carbon monoxide = 67636 kcal/kmol.

   Data: Specific heats of products of combustion in kcal/(kmol.^{o}K)

   Carbon dioxide: $C_p = 6.339 + 10.14 \times 10^{-3}T$

   Oxygen: $C_p = 6.117 + 3.167 \times 10^{-3}T$

   Nitrogen: $C_p = 6.457 + 1.389 \times 10^{-3}T$

   where T = temperature in Kelvin

3. Explain Standard heat of formation, Kopp's rule and Hess's law of constant heat summation

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: CHT 203

Max. Marks: 100 Duration: 3 Hours

CHEMICAL PROCESS PRINCIPLES

PART – A

Answer All the Questions(10 x 3 = 30)

1. Differentiate Unit Operations and Unit Processes.Give two examples for each. Write the classification of unit operations.
2. Stefan Boltzmann constant associated with radiation heat transfer is represented in FPS system as 0.171×10^{-8} Btu/hr.$(ft)^2$.$(^oR)^4$. Calculate its value in SI system.
3. A mixture of SO_2 and O_2 is at 200 kPa. Average molecular weight of mixture is 44.8. Find the partial pressure of O_2.
4. Air at temperature of 20 ^{o}C and 750 mmHg pressure has a relative humidity of80 %. Find the percentage humidity, vapour pressure of water at 20^{o}C is 17.5 mmHg.
5. Explain the systems with i) Bypass ii) Recycle
6. Define key component in a material balance problem. Give two examples.
7. Define the terms: (i) limiting reactant, (ii) conversion and (iii) Yield.
8. Write the significance of proximate and ultimate analysis of coal
9. Define adiabatic reaction temperature and theoretical flame temperature.
10. State and explain (i) Kistyakowsky Equation and (ii) Trouton's rule.

PART – B

Answer one full question from each module (5 x 14 = 70)

Module 1

11. (a) A solution of NaCl in water contains 230 gm of it per litre. The density of solution is 1.15gm/cc. Calculate:(i) Composition in wt%, (ii)Composition in mole%, (iii)Molality and (iv)Molarity.

    (b) Natural gas has the following composition by volume percent. CH_4 – 83.5%; C_2H_6 – 12.5% and rest Nitrogen. Calculate: (i) Composition in mole %, (ii) Composition in Wt% and (iii) Average molecular weight. **(7+7 = 14 Marks)**

OR

12. (a) The Prandtl number is a dimensionless group defined as $C_p\mu/k$ where C_p is heatcapacity of a fluid, μ is the viscosity of the fluid and k is the thermal conductivity ofthe fluid. For particular fluid C_p = 0.583 J/g.K, k = 0.286 W/mºC and μ= 1936 lb/hr.ft.Calculate the Prandtl Number.

    (b) A flue gas sample has the following composition by volume: CH_4 - 30 %, C_2H_4- 20%, O_2 - 10 % and the rest N_2. Calculate:

    i) Composition in weight %

    ii) Average molecular weight

    iii) Density at standard conditions**(7+7 = 14 Marks)**

Module 1I

13. Air at a temperature of 20°C and a pressure of 750 mmHg has a relative humidity of 80%. Calculate: (i) molal humidity of entering air. (ii) Molal humidity of air if its temperature is reduced to 10°C with increases in pressure of 1810 mmHg by condensing out some amount of water and (iii) the mass of water condensed from 100m^3 original wet air, by cooling and compressing to conditions of part (ii). Vapour pressure of water in mmHg at 20°C is 17.5 and at 10°C is 9.2.

OR

14. (a) A liquid mixture of benzene and toluene is in equilibrium with its vapour at 101kPa and 373 K. The vapour pressure of benzene and toluene at 373 Krespectively are 156 and 63 kPa. Find the composition of liquid and vapourphases.

    (b) The dry bulb and wet bulb temperature of an air sample are 328 K and 308 K respectively at 101.3 kPa. Determine the following using psychrometric chart: (i) Absolute humidity, (ii)Molal humidity, (iii)Percent saturation, (iv)Wet bulb temperature and (v) Humid volume.**(4+10 = 14 Marks)**

ModuleIII

15. (a) A crystallizer is charged with 7500kg of an aqueous solution of 30% Na_2SO_4. During cooling 5% of the original water is lost by evaporation. Glauber salt ($Na_2SO_4.10\ H_2O$) crystallizes. The mother liquor contains 18% salt. Calculate the weight of crystals formed, mother liquor and water lost.

    (b) Soybean seeds containing 20% oil, 65% inert solids and 15% water are leachedwith hexane and after extraction the solid residue is removed from the solution of oilin hexane. The residue analyzed 1% oil, 88% inert cake and 11% water. Calculate the percentage of oil recovered from the seeds.**(8+6 = 14 Marks)**

OR

16. A material is to be dried from 20% moisture to 1% by circulation of hot air. The fresh air contains 0.02kg of water /kg of dry air. Find the volume of fresh air required if 1000kg/hr of dried material is to be produced. The exit humidity of air is 0.09. Air enters at 300K and atmospheric pressure.

ModuleIV

17. A furnace uses coke containing 80% Carbon, 5% Hydrogen and remaining ash. The furnace operates with 50% excess air of that required for complete combustion of all the carbon charged. The solid residue (ash) contains 2% carbon. Of the carbon burnt 5% goes to CO. Calculate: (a) composition of the flue gas; (b) ash produced; (c) kg carbon lost per kg of coke burnt.

OR

18. (a) 500 kg/hr of pure sulphur is burnt with 20% excess air (based on S to SO_2). 5% sulphur is oxidized to SO_3 and rest to SO_2. Find the exit gas analysis.

    b) A gas analyzing CO_2 - 5.5%, CO - 25%, H_2 - 14%, CH_4 - 0.5%, and N_2 - 55% is burnt with 10% excess air. Calculate the Orsat analysis of the flue gas.**(7+7 = 14 Marks)**

Module V

19. Calculate the theoretical flame temperature for CO burnt with 100% excess air. Reactants enter at 366K. The heat capacities are 29.23 for CO, 29.28 for air, 54.18 for CO_2, 34.5 for O_2 and 33.1 for N_2 in J/mole K. Standard heat of reaction is -283.18kJ/kmol of CO.

OR

20. (a) The molar heat capacity of methane is given by:

$$C_p = 14.16 + 75.42 \times 10^{-3}T - 17.97 \times 10^{-6}T^2$$

Where C_p is in kJ/kmol.K and T in K. Calculate the heat required to raise one kmol of methane from 530K to 810K.

(b) Calculate standard heat of the following reaction:

$$2FeO\ (s) + \tfrac{1}{2}\ O_2 \rightarrow Fe_2O_3\ (s)$$

The standard heat of formation of FeO(s) and Fe_2O_3(s) are -268.1 kJ and -822.7 kJ respectively. **(8+6 = 14 Marks)**

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY KTU Estd. 2014

Syllabus

Module 1

Introduction to Chemical Engineering, Chemical process Industry, Unit Operations and Unit Processes. Units and Dimensions: System of Units, Basic and Derived quantities, Conversion of units, Conversion of equations- problems. Density and Specific gravity - Specific Gravity Scales. Concepts of atomic weight, equivalent weight and mole. Composition of solids, liquids and solutions - weight percent, mole percent, molarity, normality, molality, ppm

Ideal gas laws, real gas laws -Vander Waals equation (Numerical problems),

Redlich-Kwong equation, Soave-Redlich-Kwong equation, Peng-Robinson Equation (Numerical problems are not required)

Gaseous mixtures,Composition of gaseous mixtures, Average molecular weight and density, Critical properties, pseudocritical properties.

Module 2

Vapour Pressure: Effect of temperature on vapour pressure – Antoine Equation, Clapeyron Equation, Clausius-Clapeyron equation. Vapour pressure plots - Cox charts, Duhrings Lines, Ideal Solutions and non-ideal solution - Henry's law, Raoult's law, Vapour Liquid Equilibrium – x-y, T-x-y, P-x-y plots. Humidity, Dew point, Dry and Wet bulb Temperature, Adiabatic saturation, Humidity charts.

Module 3

Material Balance without chemical reactions- Introduction, key component, steps for solving material balance problems, material balance for unit operations- mixing, distillation, drying, evaporation, absorption, crystallization, extraction, leaching. Recycle, bypass and purgeoperations.

Module 4

Material Balance with chemical reactions - Definition of terms (limiting reactant, excess reactant, percentage yield, conversion, selectivity), Combustion of solid, liquid and gaseous fuels, Calorific value, proximate and ultimate analysis of coal, Orsat analysis. Material Balance problems for oxidation and hydrogenation processes. Recycle, bypass and purge operations.

Module 5

Heat capacity of solids, liquids and gaseous mixtures, Kopp's Rule, Latent heats -Heat of fusion, heat of vaporization, Estimation of Heat of Vaporization-Kistyakowsky Equation, Trouton's rule, Watson equation, enthalpy changes.

Heat effects accompanying chemical reactions - Standard heats of reaction, combustion, and formation, Hess's law of constant heat summation, Effect of temperature and pressure on heat of reaction, temperature of reaction, adiabatic reaction temperature.

Text Books:

1. "Stoichiometry and Process Calculations", K.V. Narayanan, B. Lakshmikutty, Prentice-Hall of India Pvt. Ltd.
2. "Stoichiometry", B.I. Bhatt, S.M. Vora, McGraw Hill Publishing Company Limited.
3. "Basic Principles & Calculations in Chemical Engineering", David M. Himmelblau, James B. Riggs, PHI Learning Pvt. Ltd.

Reference Books:

1. "Elementary Principles of Chemical Processes", Richard M. Felder, Ronald W. Rousseau, Wiley.
2. "Chemical Process Principles Part-I: Material and Energy Balances", O.A.Hougen, K.M.Watson, R.A.Ragatz, CBS Publishers New Delhi.

Course Contents and Lecture Schedule:

No.	Details	No. of Lectures
1	**Module 1**	**10**
1.1	Introduction to Chemical Engineering, history of Chemical Engineering, Chemical Process Industries, Unit Operations and Unit Processes.	1
1.2	Units and Dimensions, System of units, Fundamental and derived quantities, Conversion of units	1
1.3	Conversion of equations	1
1.4	Atomic weight, equivalent weight, molecular weight and mole concept, Different methods for expressing composition of solids, liquids, gases and solutions (Weight fraction, Weight %, mole fraction, mole%, molarity, molality, Normality and ppm	2
1.5	Ideal gases, Ideal Gas Equation and gas constant, Numerical problems based on ideal gas equation	1
1.6	Real gases, Equations of State: Vander Waal's equation, Numerical problems based on Vander Waal's equation	1

1.7	Other Equations of State: Redlich-Kwong equation, Soave-Redlich-Kwong equation, Peng-Robinson equation(numericals not required), Density, specific gravity and Specific gravity scale	1
1.8	Gaseous mixtures,Composition of gaseous mixtures, average molecular weight, Critical Properties, Pseudo critical properties	2
2	**Module II**	**9**
2.1	Vapor pressure and boiling point, Vapour Pressure and temperature- Clapeyron equation, Clausius - Clapeyron Equation, Antoine equation and its applications	2
2.2	Vapor pressure plots: Cox Chart, Duhrings Line	1
2.3	Ideal Solutions and non-ideal solution - Raoult's law &Henry's law	1
2.4	Vapour Liquid Equilibrium – x-y, T-x-y, P-x-y plots	1
2.5	Humidity and saturation- definition of terminologies, DBT	2
2.6	WBT, Adiabatic saturation, use of psychrometric chart	2
3	**Module III**	**9**
3.1	Law of conservation of mass, general M.B for steady and unsteady operations	1
3.2	M.B for unit operations - mixing, distillation -problems for above mentioned unit operations	2
3.3	M.B for unit operations - drying, evaporation, crystallization - problems for above mentioned unit operations	2
3.4	M.B for unit operations - absorption, extraction, leaching- problems for above mentioned unit operations	2
3.5	Recycle, bypass and purge operations - Significance	2
4	**Module IV**	**9**
4.1	M.B with chemical reactions: Definition of terms-limiting reactant, excess reactant, % yield, conversion and selectivity.	1
4.2	M.B problems for unit processes: problems for oxidation and hydrogenation.	2
4.3	Fuels and Calorific value: Solid, liquid and gaseous fuels, Gross and Net calorific value , Coal analysis (proximate and ultimate analysis)	2
4.4	Combustion: Air requirement, ORSAT analysis	2
4.5	Bypass, Recycling and purging operations: Chemical Reactions with recycle, purging, advantages	2

5	Module V	8
5.1	Energy Balance- Specific heat, variation with Temperature, heat capacity of solids, liquids and gaseous mixtures, Kopp's Rule	2
5.2	Latent heats: Heat of fusion, heat of vaporization, Estimation of Heat of Vaporization-Kistyakowsky Equation, Trouton's rule, Watson equation.	1
5.3	Thermo-chemistry: Heat of chemical reaction, Heats of formation and combustion, Hess's law of constant heat summation	2
5.4	Effect of temperature on heat of reaction, Relation between std. heat of reaction, heat capacity and temperature	1
5.5	Adiabatic reactions, flame temperature: Theoretical and actual flame temperature	2

CHT 205	FLUID AND PARTICLE MECHANICS	CATEGORY	L	T	P	CREDIT
		PCC	3	1	0	4

Preamble: This course introduces students to the concepts of fluid and particle mechanics that are relevant and used for applications in chemical engineering. This course summarizes various properties of fluids and distinguishes the different types of flow systems; examine the mathematical models for flow behaviour in different systems utilizing the principles of kinematics, explain the concepts of flow in boundary layers and select suitable flow measuring devices, fluid moving machineries and distinguish the different types of valves used in process industries. It also outlines the fluid flow around immersed solids and calculates the pressure drop in fluidized beds and packed beds.

Prerequisite: Nil

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

CO 1	Apply the basic properties and transport laws to fluid in different conditions like statics and dynamics
CO 2	Apply the fluid flow principles in the application of the mass, momentum and energy equations.
CO 3	Design a piping network using the concept of fluid dynamics
CO 4	Design a fluidized bed and a packed bed using the concept of fluid dynamics considering its application.
CO 5	Select valves, pumps and flow measuring devices in process industries with the knowledge of the basic principles.

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	1	1					2	1		2
CO 2	3	3	3	3	3				2	1		2
CO 3	3	3	3	2					1	1		2
CO 4	3	3	3	2					2	1		2
CO 5	3	2					2		2	2		2

Assessment Pattern

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

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): To apply the basic properties and transport laws to fluid in different conditions like statics and dynamics

1. Differentiate between absolute viscosity and apparent viscosity.

2. What is rheology?. Explain the rheological classification of fluids.

3. Define Pascal's law.

Course Outcome 2 (CO2): To apply the fluid flow principles in the application of the mass, momentum and energy equations.

1. An oil of specific gravity 0.7 is flowing through a pipe of diameter 30 cm at the rate 500 lit/sec. Find the head loss due to friction and power required to maintain the flow for a length of 1000 m. Take viscosity is 5 cp and $f = 0.79\ NRe^{0.25}$.

2. Derive momentum balance equation.

3. What are the correction factors incorporated in the Bernoulli's equation. Explain

Course Outcome 3(CO3): To design a piping network using the concept of fluid dynamics

1. Derive the f v/s NRe relationship in turbulent flow.

2. Write the applications of friction factor chart.

3. Exhaust gases from a power plant passes through a 30 x 45 cm rectangular duct at an average velocity of 15 m/s. The total length of the duct is 80 m and there are two 90^0 bends (Kf = 0.9). The

gas is at room temperature and about 1 atm. And the properties are similar to those of air. Calculate the pressure drop in the duct and the power required to overcome the pressure losses.

Course Outcome 4 (CO4): To design a fluidized bed and a packed bed using the concept of fluid dynamics considering its application.

1. Derive the equation for minimum fluidization Velocity.

2. Define Drag Coefficient.

3. A bed containing 35000 Kg of sand particles (Dp = 0.16mm) is to be fluidized with air at 400C and 20 Kg/cm^2 pressure in cylindrical vessel 2m in diameter. The density of sand particle is 2.7 gm/cc. The viscosity of air at operating condition is 0.032 cp. Calculate

    1. The minimum height of the fluidized bed
    2. Pressure drop in the fluidized bed

(Critical superficial velocity assuming $\epsilon m = 0.55$)

Course Outcome 5 (CO5): To judge the selection of valves, pumps and flow measuring devices in process industries with the knowledge of the basic principles.

1. Compare Rotary pumps and Reciprocating pumps.

2. What are characteristics curves in centrifugal pump?

3. Write the classification of valves. With neat diagram explain the working of ball valve.

Model Question paper

QP CODE: **Reg No:_____**

PAGES:3 **Name :_____**

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

Course Code: CHT 205

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

CHT 205 FLUID AND PARTICLE MECHANICS

(2019-Scheme)

PART A

(Answer all questions, each question carries 3 marks)

1. Define Newton's law of viscosity.
2. Differentiate between Newtonian and Nonewtonian fluids.
3. Why the kinetic energy correction factor is included in the Bernoulli's equation.
4. Explain nose bleeding and shortness of breath at high elevation.
5. Derive Hagen Poiseuille equation.
6. What is frictional velocity?
7. Differentiate between Particulate fluidization and aggregate fluidization.
8. What are the assumptions in the derivation of Ergun equation?
9. What is NPSH? Explain.
10. Differentiate between Pipes and tubes. (10x3 = 30 marks)

PART B

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

MODULE I

11. a) A tubular centrifuge is to separate chlorobenzene with a density of 1090 Kg/m^3 from an aqueous wash liquor having a density of 1010 Kg/m^3. The centrifuge has an inside dia of 200mm and rotates at 10000 rpm. The free liquid surface inside the bowl is 60 mm from the axis of rotation. If the centrifuge bowl is to contain equal masses of two liquids. What should be the radial distance from the axis to the top of the over flow of the heavy liquid.

b) Derive Barometric equation. (10+4 = 14 marks)

12. a) A simple U tube manometer is installed across an orifice meter. The manometer is filled with mercury (specific gravity=13.6) and the liquid above mercury is CCl_4 (specific gravity = 1.6). The manometer reads 200mm. Calculate the pressure difference is N/m^2.

b) With neat diagram explain the working of gravity decanter. (8+6 = 14 marks)

MODULE II

13. Derive Bernoulli's equation for an ideal fluid and modify is to account for frictional losses. (14 marks)

14. a) 1250 lit/sec of water is to be pumped from a reservoir through a steel pipe 25 mm dia and 30 m long to a tank 20 m higher than its reservoir. Calculate theoretical power required.

b) Explain the statistical nature of turbulence. (10+4 = 14 marks)

MODULE III

15. Derive universal velocity distribution equation. Mention its limitations. (14 marks)

16.a) Glycerine of viscosity 0.9 cp and specific gravity 1.26 is pumped along a horizontal pipe of 6.5 m long and dia 1 cm at a flow rate of 1.8 lit/sec. Calculate the frictional loss in the pipe due to friction effects.

b) Derive the equation for shear stress distribution in pipe under laminar flow.

(7+7 = 14 marks)

MODULE IV

17. a) Explain about the different regimes of fluidization. Write the application of fluidization techniques in industry.

b) What is slugging in the fluidized bed. (10+4 = 14 marks)

18. A partial oxidation is carried out by passing air with 1.2 mol% hydrocarbon through 40mm tubes packed with 4m of 5mm cylindrical catalyst pellets. The air enters at 360C and 3 atm with a superficial velocity of 1m/s. What is the pressure drop in the packed bed. How much would be the pressure drop reduced by using 6mm pellets. Assume porosity is 0.4.
(14 marks)

MODULE V

19.a) With neat diagram explain the working of centrifugal pump.

b) Select a suitable pump for the circulation of lube oil in the compressor. With neat diagram explain the working of that pump. (7+7 = 14 marks)

20.a) A pump draws benzene at 25 C from a tank, whose level is 2.6 m above the pump inlet. The suction line has a head loss of 0.8 Nm/N. The atmospheric pressure is measured to be 98.5 Kpa (abs). Calculate the available NPSH. The vapour pressure of benzene is 13.3 Kpa (abs).

b) Explain the principles of operation of Pitot tube. (10+4 =14 marks)

Syllabus

Module 1

Definition of fluid, Continuum mechanics, Newton's law of viscosity. Physical properties of fluid: Density, specific weight, specific volume, specific gravity, viscosity, compressibility & elasticity, surface tension & capillarity. Variation of viscosity and density with temperature and pressure. Rheology of fluids, Rheological Classification of fluids.

Pascal's law, Hydrostatic equilibrium in gravity and centrifugal field. Barometric equation. Principles of continuous gravity decanter and centrifugal decanter. Lapse rate. Principles of Manometer-Simple manometer, inclined tube manometer.

Module 2

Introduction to fluid flow:Flow field, Eulerain and Lagrangian approach, velocity potential, stream function, circulation and vorticity. Stream line, Path line, Streak line, Stream tube Classification of flow. Reynolds experiment, Reynolds number, Turbulence, Reynolds stress, Flow in boundary-layers, Boundary-layer formation in straight tubes, Boundary-layer separation and wake formation.

Basic equations of fluid flow: Continuity Equation, Macroscopic momentum Balance (Navier stokes equation), Bernoulli's Equation. Kinetic energy correction factor. Correction for fluid friction, Pump work, and compressible flow in Bernoulli's equation.

Module 3

Laminar flow of incompressible fluids in conduits, Shear stress and Velocity distribution, Maximum and average velocity-Hagen Poiseuille equation- Friction factor and Reynolds number relationship in laminar flow. Turbulent flow of incompressible fluids in pipes and conduits: Universal velocity distribution equation, Friction factor and Reynolds number relationship-Nikuradse and Karman equation-Blasius equation (derivation not required), Prandtl one seventh power law-Friction factor chart-Friction from changes in velocity or direction-Sudden expansion and contraction-Effect of fittings and valves. Hydraulic radius and Equivalent diameter.

Module 4

Flow past immersed bodies - Drag coefficient. Solid–fluid contacting systems. Flow through packed bed - Ergun equation -Kozney-Carman equation - Blake Plummer equation. Fluidization - The phenomenon of fluidization, type of fluidization, Different regimes of fluidization,. Advantages and disadvantages of fluidized beds and packed bed. Industrial applications of fluidized bed and packed bed. Pressure drop calculation, minimum fluidizing velocity, effect of pressure and temperature on fluidized bed behaviour.

Module 5

Pumps, fan, blower, compressor and its classification. Types of pumps (limited to application and operation). Centrifugal pumps-Various losses, Characteristic curves, NPSH, Cavitation, Specific speed and Priming .

Pipe and tubing, Joints and fittings, Valves (diagram and operation of Gate valves and globe valves, diaphragm valves, butterfly valve and ball valves, Check valves), Equivalent length.

Flow measurement devices, Flow rate equation for Venturi; Orifice; flow nozzle; Pitot tube; Rectangular, Triangular & Trapezoidal weir; Rotameter.

Reference Books

1. McCabe W.L., Smith J.C., Harriot P., Unit Operations of Chemical Engg. McGraw Hill
2. Frank M. White, Fluid mechanics. McGraw Hill.
3. Y. Nakayama, Fluid mechanics. Butterworth-Heinemann.
4. Coulson J.M. & Richardson J.F., Chemical Engg. Vol. 1, Pergamon
5. Foust AS, Wenzel LA, Clump CW, Maus L, Andersen LB. Principles of unit operations. John Wiley & Sons.
6. Noel de Nerves, Fluid Mechanics for Chemical Engineers, McGraw Hill.
7. Streeter V.L., Fluid Mechanics, McGraw Hill

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Properties, classification of fluid and Fluid statics (9hrs)**	
1.1	Definition of fluid, Newton's law of viscosity. Physical properties of fluid	3hrs
1.2	Rheology of fluids	1hr
1.3	Pascal's law, Hydrostatic equilibrium in gravity and centrifugal field	2hrs
1.4	Barometric equation and Lapse rate	1hr
1.5	Principles of continuous gravity decanter and centrifugal decanter	1hr
1.6	Principles of Manometer-Simple manometer, inclined tube manometer.	1hr
2	**Introduction to fluid flow and Basic equations of fluid flow(10hrs)**	
2.1	Classification of flow, Reynolds experiment and turbulence	2hrs
2.2	Flow field, Eulerain and Lagrangian approach, velocity potential, stream function, circulation and vorticity. Stream line, Path line, Streak line, Stream tube.	2hrs
2.3	Boundary layer and wake formation	1hr
2.4	Basic equations of fluid flow- mass, momentum and energy	5hrs
3	**Internal flow of incompressible fluids in pipes and conduits (8 hrs)**	
3.1	Shear stress and Velocity distribution in laminar flow	2hr
3.2	Hagen Poiseuille equation, Friction factor	1hr
3.3	Universal velocity distribution equation	1hr
3.4	Friction factor and Reynolds number relationship in turbulent flow	2hrs
3.5	Friction factor chart-Friction from changes in velocity or direction	2hr
4	**Flow past immersed bodies (External flow) (9hrs)**	

4.1	Flow through packed bed	3hrs
4.2	Fluidization	2hrs
4.3	calculation, minimum fluidizing velocity and pressure drop	3hrs
4.4	Effect of pressure and temperature on fluidized bed behaviour	1hr
5	**Pumps, Valves and Flow measuring devices (9 hrs)**	
5.1	Pumps	4hrs
5.2	Valves	2 hrs
5.3	Flow measuring devices	3 hrs

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY KTU Estd. 2014

CHL 201	COURSE NAME CHEMICAL TECHNOLOGY AND ENVIRONMENTAL ENGINEERING LAB	CATEGORY	L	T	P	CREDIT
		PCC	0	0	3	2

Preamble: The Chemical Technology and Environmental Engineering lab is equipped with viscometers, BOD incubator, spectrophotometer, water bath, digital balance etc. to carry out the basic experiments related to the chemical technology and Environmental Engineering. Experiments like iodine value, BOD, COD, analysis of soap, etc. are performed in the lab.

Prerequisite: Nil

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

CO 1	Analyse and estimate parameters for the selected chemicals.
CO 2	Develop skills to use analytical and instrumental methods for measurement of parameters relevant to chemical engineering.
CO 3	Develop skills of accuracy in experimentation, interpret the experimental result and suggest its area of application.
CO 4	Demonstrate capacity to work in team and exhibit knowledge of safety, health and environment by practicing laboratory ethics

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									
CO 2		3	3									3
CO 3		3	3	3	3				3	3		3
CO 4			3			3	3	3	3			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	: 15Marks
(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.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Perform the experiments to determine the quality of bleaching powder.
2. Conduct the experiment to find the iodine value of the given sample of oil.
3. Determine the moisture content, alkali content, and Total Fatty Matter in the given sample ofsoap.

Course Outcome 2 (CO2)

1.Find the viscosity of the given oil at different temperatures using Redwood viscometer.
2. Estimate the BOD of the given sample of water using BOD incubator.
3. Estimate the Calorific value of the given gas using Junkers Gas Calorimeter

Course Outcome 3(CO3):

1. Mention the experiment to determine the quality of water.
2. Estimate the available chlorine in the given sample of bleaching powder and analysis its quality.
3. Determine the hardness of the given sample of water and report on the quality of water.

Course Outcome 4 (CO4):

1. Evaluating the experimentation capacity of student's in group.

2.Analysing the interpretation skill of results with group discussion.

3. Reporting of experimental data, results and report within the stipulated time through team effort.

LIST OF EXPERIMENTS (Minimum of 8 mandatory)

1. Determine the Iodine value of the given oil sample.
2. Determine the available chlorine in bleaching powder.
3. Preparation and analysis of soap.
4. Estimate the COD of the given water sample.
5. Estimate the BOD of the given water sample.
6. Estimate the total solids and dissolved solids content of the given wastewater sample.
7. Determine the sucrose content in given sugar sample.
8. Determine the flash and fire point of the oil sample.
9. Analysis of oil and grease in wastewater sample.
10. Determination of ammoniacal nitrogen.
11. Determination of Sulphate in water sample
12. Determination of viscosity using Redwood viscometer.
13. Determination of Heavy metals in water sample
14. Determination of Optimum coagulant using Jar Test apparatus
15. Study of Equipments-Gas Chromatography, Flamephotometer, Junkers Gas Calorimeter, Spectrophotometer, Atomic Absorption Spectrophotometer.

Reference Books

1. Vogels Textbook of quantitative chemical analysis ELBS/Longman 1989
2. *"Standard Methods for the Examination of Water and Wastewater"*, American public health association, New York.
3. F.W. Fifield and P.J. Haives Blackie, *"Environmental Analytical Chemistry"*, Academic and professional glasgow.
4. Sawyer and McCarty, *"Chemistry for Environmental Engineers"*, Tata Mc-Graw Hill.
5. *"Manual of Standards of Quality for Drinking Water Supplies",* Indian Council of MedicalResearch, New Delhi.
6. *"International Standards for Drinking Water"* — World Health Organization.
7. "IS 2490 - 1981, IS 3306 - 1974, IS 3307 - 1977, IS 7968 - 1976, IS 2296 - 1974*",* Bureauof Indian Standards, New Delhi.

CHL 203	CHEMISTRY LAB FOR PROCESS ENGINEERING	CATEGORY	L	T	P	CREDIT
		PCC	0	0	3	2

Preamble: Chemistry laboratory experiments are designed for inculcating the Practical Chemistry knowledge and micro-skills of a Chemical Engineering student. By properly conducting the experiments qualities like scientific aptitude, observation skill, analytical thinking etc will be enhanced. Varieties of experiments from analytical and physical chemistry are introduced in the syllabus which are very useful for a process engineer.

Prerequisite: Basic knowledge in Engineering Chemistry Laboratory experiments

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

CO 1	Explain the thermodynamics of solutes in a solvent and apply this knowledge in higher semester practical sessions.
CO 2	Describe the mutual solubilities of liquids and apply this idea in solvent extraction
CO 3	Construct a phase diagram of bi and tri component systems and predict the composition of mixtures at various temperature.
CO 4	Evaluate the capacity of coagulating electrolytes and synthesize colloidal solutions and
CO 5	Investigate adsorption isotherms and apply this knowledge in various industrial processes
CO 6	Quantify the analyte using electrochemical analytical techniques such as conductometry and potentiometry

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		2							2
CO 2	3	3	2				3		2			3
CO 3	3	2	2				2		2			2
CO 4	3	3	3	2			2		2		2	2
CO 5	3	3	2	2		2	3		2		2	
CO 6	2	3	3		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.

LIST OF EXPERIMENTS (Minimum of 8 mandatory)

1. Enthalpy of solution of oxalic acid or benzoic acid by solubility method.
2. Mutual solubility curve of phenol and water (or trimethylamine and water) and determination of CST
3. Determine the concentration of aqueous KCl solution by studying the mutual solubility of phenol and water
4. Distribution coefficient of Iodine between an organic liquid (CCl_4, CS_2 or Kerosene) at room temperature.
5. Partition coefficient of Succinic acid between water and ether.
6. Determine sodium and potassium in fruit juice using flame photometer.
7. Investigate the inversion of cane sugar in the presence of acid at room temperature.
8. Determine the end point of titration between CH_3COOH and NaOH conductometrically.
9. Determine the composition of mixture of acetic acid and hydrochloric acid by conductometric titration.
10. Study the kinetics of the reaction between potassium persulphate and potassium iodide
11. Study the kinetics of decomposition the complex formed between sodium nitroprusside and sodium sulphide spectrophotometrically and find the order and rate constant of the reaction.
12. Investigate the adsorption of iodine from alcoholic solution by charcoal and examine the validity of Freundlich and Langmuir isotherms.
13. Titration of Zn(II) by $K_4[Fe(CN)_6]$ potentiometrically and verify the complex $K_2Zn_3[Fe(CN)_6]$.
14. Determine the precipitating values of 0.2M KCl, 0.005M K_2SO_4 and 0.0005M $K_3[Fe(CN)_6]$ for ferric hydroxide sol.
15. Determine the critical micelle concentration of soap by the study of change of spectral behaviour of pinacynol chloride or Rhodamine 64.

16. Determine the molecular weight of a non-volatile substance (acetanilide/urea/naphthalene/anthracene/thiourea etc..) using Rast method- camphor as solvent.

Reference Books

1. F. W. Fifield, Principles and Practice of Analytical Chemistry, Wiley-Blackwell; 5th edition 2000

2. J. B. Yadav, Advanced Practical Physical Chemistry, Goel Publications, 2017 Edition

3. Gary D. Christian, Analytical Chemistry, 6th Edition Wiley; Sixth edition (2007)

4. D. N. Bajpai, O. P. Pandey and S. Giri, *Practical Chemistry,* S Chand & Co Ltd, 2015 Edn

SEMESTER -3

MINOR

CHT 281	INTRODUCTION TO CHEMICAL ENGINEERING	CATEGORY	L	T	P	CREDIT	Year of introduction
		VAC	3	1	0	4	2019

Preamble:

This course introduces students to some basic introduction of Chemical engineering. Familiarises students with some concepts of units and equations of state. It also provides a brief overview of unit operations and unit processes, modes of heat transfer, chemical reactions, introduction to process instrumentation and control, safety in chemical process industries and environmental engineering.

Prerequisite: A basic course in chemistry and mathematics

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

CO 1	Explain the history, role of chemical engineering and chemical engineering profession
CO 2	Explain the basic concept of units, dimensions, various methods of expressing compositions and equations of state.
CO 3	Explain various unit operations and unit processes
CO 4	Explain the modes of heat transfer, fluid flow, different chemical reactions and reactors.
CO 5	Explain the basic concepts of flow diagrams, process instrumentation and control
CO 6	Explain the importance of safety in process industries and waste treatment

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											
CO 4	3											
CO 5	3											
CO 6	3											

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	20
Understand	20	20	60

Apply	20	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): Explain the history, role of chemical engineering and chemical engineering profession

1 Chemical engineers work in various roles in an industry. List any three roles.

2. Discuss the role of chemical engineers in controlling atmospheric pollution.

3. Classify chemical industries to give any five classes with an example

Course Outcome 2 (CO2): Explain the basic concept of units, dimensions, various methods of expressing compositions and equations of state.

1. Specify three terms for expressing the composition of an ore mixture.

2. Illustrate the equation of state

3. The mass velocity of a gas through a duct is 1000 kg/m^2 h. Express the velocity in lb/ ft^2 s

Course Outcome 3(CO3): Explain various unit operations and unit processes

1. Differentiate physical adsorption and chemical adsorption

2. Explain any two polymerization reactions and its industrial application

3. Distinguish unit operations and unit processes with examples

Course Outcome 4 (CO4): Explain the modes of heat transfer, fluid flow, different chemical reactions and reactors.

1. Explain different modes of heat transfer with example

2. Distinguish between laminar and turbulent flow

3. Explain different classification of chemical reactions with an example

Course Outcome 5 (CO5): Explain the basic concepts of flow diagrams, process instrumentation and control

1. Identify the basic information provided in the Process Flow Diagram

2. Explain the principle of venturimeter

3. Enumerate the need for using U-tube manometer

Course Outcome 6 (CO6): Explain the importance of safety in process industries and waste treatment

1. Identify the role of safety in chemical process industries.

2. Explain the importance of safety measure in chemical industries with the help of Bhopal incident

3. Describe an industrial wastewater treatment facility

Model Question paper

QP Code:

Reg No.:_____ Name:_____

Course Code: CHT 281

Course Name: INTRODUCTION TO CHEMICAL ENGINEERING

Max. Marks: 100 Duration: 3 Hours

(2019-Scheme)

PART A

Answer all questions, each carries 3 marks.

1. Chemical engineers works in various roles in an industry. List any three roles.
2. Point out the major fields of application of Chemical Engineering
3. Give three terms of expressing compositions of a gas mixture.
4. Illustrate the equation of state.
5. Distinguish between extraction and leaching
6. Classify the size reduction equipments with one example
7. Explain different modes of heat transfer
8. Define the order of reaction and molecularity of a chemical reaction.
9. How solid wastes are classified?
10. State any 3 general process hazards that may arise in an industry

(10x3=30)

PART B

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

Module –1

11. a) Point out any six chemical industries in India.

b) Distinguish between the role of chemist and chemical engineer in an industry?

12. a) List any six major Chemical Industries in India. Specify raw materials, processes for each of these industries.

b) List important milestones in the history of Chemical Engineering.

Module –2

13. a) Compare the pressures given by the ideal gas law and Vander Waals Equations for 1gmole of CO_2 occupying a volume $381x10^{-6}$ m^3 at 40^oC. a = 0.3646 $Nm^4/gmol^2$; b=$4.28x10^{-5}m^3/gmol$

b) Differentiate molarity, molality and normality.

14. a) A solution of NaCl in water contains 230 g NaCl per litre at 20 deg C. The density of the solution at this temperature is 1.148 g/cc. Express the composition of the solution in

(i) Weight % (ii) Volume % (iii) Molality

b) Specify partial pressure, vapour pressure and total pressure of a system.

Module –3

15. a) Name the unit operation that utilizes the principle of separation of components based on the relative volatility? Differentiate the same with evaporation?

b) Explain saponification process and its industrial application

16. a) Write various mechanisms by which size reduction may be achieved.

b) List any one example each for size reduction and size separation equipment?

Module –4

17. a) Differentiate between Mixed flow reactor and Plug flow reactor.

b) With a schematic diagram explain working of a venturimeter

18. a) With a schematic diagram explain working of a thermocouple.

b) Explain application of P & ID diagram and Draw P&ID symbols of any five vessels used in chemical industries

Module –5

19. a) What were the possible causes of Bhopal gas tragedy.

b) Describe solid waste management

20. a) Explain the Case study of Effect of Aerial Spraying of Endosulfan on Residents of Kasargod, Kerala.

1. b) Discuss a typical wastewater treatment system

Syllabus

Module 1

Introduction to Chemical engineering: history of Chemical engineering, role of Chemical engineering- broad overview; Chemical industries in India; introduction to Chemical engineering profession; introduction to chemical plant operation; process development and process design.

Module 2

Basic concepts: units and dimensions, systems of units, conversion and conversion factors of units, concept of mole, weight percent, mole percent, normality, molarity, molality, vapour pressure, partial pressure, concept of ideal gas and equations of state.

Module 3

Overview of unit operations such as distillation, absorption, adsorption, extraction, leaching, drying, crystallization and evaporation; Size separation and size reduction. Overview of unit processes like saponification. polymerization, biodiesel formation and hydrogenation

Module 4

Modes of heat transfer- principles of conduction, convection and radiation, heat exchangers. Fluid flow – laminar and turbulent flow, introduction to transportation of fluids.

Classification of chemical reactions, order of reaction, rate equation, Arrhenius equation, conversion and yield, batch reactor, mixed reactor and plug flow reactor

Block diagram, Process flow diagram, elements of feedback control loop, basic concepts of P & I diagram, Introduction to process instrumentation and control. Measuring instruments: thermocouple, venturimeter, U-tube manometer

Module 5

Introduction to safety in chemical process industries, basic concepts, Case study: Bhopal gas tragedy. Introduction to Environmental Engineering- basic concepts, Typical wastewater, air and solid waste management system. Case study: Effect of Aerial spraying of Endosulfan on residents of Kasaragod, Kerala.

Text Books

1. K. V. Narayanan and B. Lakshmikutty, “Stoichiometry and Process Calculations”, PHI learning Pvt. Ltd., Delhi

Reference Books

1. Badger and Bachero, “Introduction to Chemical Engineering”, McGraw Hill

2.McCabenW.L., Smith J.C. and Harriott P. “Unit Operations in Chemical Engineering”, McGraw Hill

3.Pushpavanam S., "Introduction to Chemical Engineering", PHI Learning Pvt. Ltd.

No	Topic	No. of Lectures
1	**Introduction to Chemical engineering (6Hrs)**	
1.1	History of Chemical engineering	1Hr
1.2	Role of Chemical engineering	2Hr
1.3	Chemical industries in India	1Hr
1.4	Chemical plant operation, Process development process design	2 Hr
2	**Basic concepts in units and conversion (10 Hrs)**	
2.1	Units and dimension, systems of units	1 Hr
2.2	Conversion and conversion factors of units	2Hr
2.3	Concept of mole, weight percent, mole percent	2Hr
2.4	Concept of normality, molarity, molality	2Hr
2.5	Vapour pressure, partial pressure	1Hr
2.6	Concept of ideal gas and equation of state.	2Hr
3	**Unit Operations and Unit Processes (10 Hrs)**	
3.1	Overview of unit operations and Overview of unit processes	1Hr
3.2	Distillation, absorption, adsorption	2Hr
3.3	Extraction, leaching	1Hr
3.4	Drying, Crystallization and evaporation	2Hr
3.5	Size separation and size reduction	2Hr
3.6	Saponification. Polymerization,	1Hr
3.7	Biodiesel formation and hydrogenation	1Hr
4	**Physical and Chemical transport (11 Hrs)**	
4.1	Modes of heat transfer- principles of conduction, convection and radiation, heat exchangers.	1Hr
4.2	Fluid flow – laminar and turbulent flow, introduction to transportation of fluids.	1Hr
4.3	Classification of chemical reactions, order of reaction , rate equation, Arrhenius equation,	2Hr
4.4	Conversion and yield, batch reactor, mixed reactor and plug flow reactor	2Hr
4.5	Block diagram , Process flow diagram, elements of feedback control loop	1Hr
4.6	Basic concepts of P & I diagram	1Hr
4.7	Introduction to process instrumentation and control. Measuring instruments	1Hr
4.8	Thermocouple, venturimeter, U-tube manometer	2Hr
5	**Environmental and safety in Chemical industries (8 Hrs)**	
5.1	Introduction to safety in chemical process industries, basic concepts	2Hr

5.2	Case study: Bhopal gas tragedy	1Hr
5.3	Introduction to Environmental Engineering- basic concepts	1Hr
5.4	Typical wastewater, air and solid waste management system.	2Hr
5.5	Case study: Effect of Aerial spraying of Endosulfan on residents of Kasargod , Kerala.	2Hr

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
KTU
Estd. 2014

SEMESTER -4

CHT 202	CHEMICAL ENGINEERING THERMODYNAMICS	CATEGORY	L	T	P	CREDIT
		PCC	3	1	0	4

Preamble:

This course aims to impart the basic concepts of Classical Thermodynamics. It covers the laws of Thermodynamics and their applications to open and closed systems and property relations for pure substances and solutions. Concepts of Ideal and Non ideal solutions, Phase equilibrium with special emphasis to Vapour Liquid Equilibria, Activity coefficient models and Chemical Reaction Equilibria are also covered. The major focus is to build a strong foundation in the subject and to familiarise with the applications of thermodynamic principles in chemical engineering problems.

Prerequisite: Knowledge of fundamental Physics, Chemistry and Mathematics

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

CO 1	Apply the laws of thermodynamics to analyse various processes
CO 2	Define thermodynamic properties and processes of a system
CO 3	Relate various thermodynamic properties to easily measurable properties
CO 4	Calculate the change in properties when given substances are mixed under specified conditions
CO 5	Construct phase diagrams and Explain VLE of completely miscible, partially miscible and immiscible liquids
CO 6	Evaluate equilibrium constant, composition and degrees of freedom for reactions taking place in a given mixture of components at given conditions of temperature and pressure

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
CO 2	3	2	2									3
CO 3	3	2	2	3								3
CO 4	3	3	3	3	2							3
CO 5	3	2	2	3	2							3
CO 6	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. Explain the application of the Zeroth law of thermodynamics in temperature measurement

2. Develop expression for maximum velocity of fluid flow through a horizontal pipe.

3. Explain the application of the Third law of thermodynamics with suitable example.

Course Outcome 2 (CO2)

1. Differentiate between intensive properties and extensive properties with suitable examples

2. Define primary properties and energy properties

3. Differentiate between reversible and irreversible processes

Course Outcome 3(CO3):

1. Derive the fundamental property relations
2. Derive Clausius- Clapeyron equation from fundamental property relations
3. Derive expression for Joule-Thomson coefficient in terms of measurable properties

Course Outcome 4 (CO4):

1. Define partial molar properties.
2. Define chemical potential.
3. Define excess properties.

Course Outcome 5 (CO5):

1. Illustrate VLE for completely miscible system with the help of a neat phase diagram.
2. Explain with a neat phase diagram the VLLE in a partially miscible system
3. Explain the vapour liquid equilibria in a system of two immiscible liquids

Course Outcome 6 (CO6):

1. Explain the different methods of determination of equilibrium constant of a given reaction
2. Derive the effect of temperature on equilibrium constant
3. Obtain the degrees of freedom of gaseous system containing CO, CO_2, N_2, O_2 and CH_4

Model Question paper

QP CODE: PAGES:4

Reg No:_____

Name :_____

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

MONTH & YEAR

Course Code: CHT202

Max. Marks: 100 Duration: 3 Hours

CHEMICAL ENGINEERING THERMODYNAMICS

(2019-Scheme)

Part A

(Answer ***all*** questions. Each question carries 3 Marks)

1. Comment on the limitations of first law of thermodynamics with suitable examples.
2. Deduce Raoult's law from Lewis Randall rule.
3. Give any three Maxwell's equations.
4. Estimate the approximate pressure at which a boiler is to be operated if it is desired to boil water at 150^{o}C. Assume that no other data is available except that water boils at 100^{o}C at 0.10133 MPa with the enthalpy of vaporization being 2256.94 kJ/kg.
5. List any three applications of Gibbs-Duhem equation.
6. Give the criterion of stability for a binary mixture.
7. State Duhem's Theorem. Give the number of independent extensive variables required to completely define the state of a closed system with benzene and its vapour in equilibrium.
8. Define excess property. List the circumstance under which the property change of mixing and the excess properties are identical.
9. Water vapour decomposed according to the following reaction:

$$H_2O \rightarrow H_2 + \tfrac{1}{2} O_2$$

Derive the expression for the mole fraction of each species in terms of the extent of reaction assuming that the system contained n_0 moles of water vapour initially.

10. Determine the degrees of freedom for a system prepared by partially decomposing $CaCO_3$ into an evacuated space.

(10 × 3 = 30 marks)

PART B

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

Module - I

11. a. Water at 90°C flowing at the rate of 2 kg/s mixes adiabatically with another stream at 30°C flowing at the rate of 1 kg/s. Estimate the rate of entropy generation and rate of energy loss due to mixing. Take T_0 = 300 K. (8)

    b. Water flows through a horizontal coil heated from outside. During its passage, it changes state from liquid at 200 kPa and 80°C to vapor at 100 kPa and 125°C. The entering and exit velocities are 3 m/s and 200 m/s respectively. Determine the heat transferred through the coil per unit mass of water. H_{inlet} = 334.9 kJ/kg; H_{outlet} = 2726 kJ/kg. (6)

12. a. An ideal gas undergoes the following sequence of mechanically reversible processes in a closed system: (10)

    a). From an initial state of 70°C and 1 bar, it is compressed adiabatically to 150°C.

    b). It is then cooled from 150°C to 70°C at constant pressure.

    c). Finally, it is expanded isothermally to its original state.

    Calculate W, Q, ΔU and ΔH for each of the three processes and for the entire cycle. Take Cv = (3/2)R and Cp =(5/2)R.

    b. State and prove the Clausius inequality. (4)

Module - II

13. a. Derive expressions to show the effect of temperature and pressure on fugacity. (7)

    b. The volume coefficient of expansion of water at 373 K is 7.8×10^{-4} K^{-1}. Calculate the change in entropy when the pressure is increased from 1 bar to 100 bar. At 373 K, density of water is 958 kg/m^3. (7)

14. a. Using Redlich-Kwong equation determine the molal volumes of saturated liquid and saturated vapour of toluene at 300 K. The saturation pressure of methyl chloride at 300 K is 2 bar. The critical temperature and pressure are respectively 591.8 K and 41.09 bar. (10)

    b. Illustrate the Pressure –Temperature diagram for a pure material. (4)

Module - III

15. a. Derive coexistence equation from Gibbs-Duhem equation. List the major applications of coexistence equation. (9)

    b. The need arises in a laboratory for 2000 cm^3 of an antifreeze solution consisting of 30 mol % methanol in water. Determine the volumes of pure methanol and pure water at 25°C to be mixed to form 2000 cm^3 of antifreeze at 25°C. Partial molar volumes of methanol and water in a 30 mol % methanol solution and their pure-species molar volumes, both at 25°C are (5)

    Methanol: $\bar{V}_1 = 38.632\ cm^3\ mol^{-1}$; $V_1 = 40.727\ cm^3\ mol^{-1}$

    Water : $\bar{V}_2 = 17.765\ cm^3\ mol^{-1}$; $V_2 = 18.068\ cm^3\ mol^{-1}$

16. a. Explain the effect of pressure and temperature on activity coefficient. (9)

    b. Show that for equilibrium between phases of a pure substance, the fugacities in both phases should be equal. (5)

Module - IV

17. a. The azeotrope of the n-propanol-water system has a composition 56.83% water with a boiling point of 360.9 K at a pressure of 101.3 kPa. At this temperature, the vapour pressures of water and propanol respectively are 64.25 kPa and 60.7 kPa. Evaluate the activity coefficients for a solution containing 20% water through the Van Laar equations. (9)

    b. Explain the principle steam distillation. (5)

18. a. A mixture contains 35% (mol) methanol (A), 40% ethanol (B) and the rest n-propanol (C). The liquid solution may be assumed to be ideal and perfect gas law is valid for the vapour phase. Calculate the bubble point and vapour composition at a total pressure of 101.3 kPa. (14)

    The vapour pressures of the pure liquids are given below:

Temp. K	333	343	353	363
P_A, kPa	81.97	133.29	186.61	266.58
P_B, kPa	49.32	73.31	106.63	166.61
P_C, kPa	39.32	62.65	93.30	133.29

Module - V

19. a. The reaction is $N_2(g) + O_2(g) \rightarrow 2\,NO(g)$ is carried out at 2700°C and 2025 kPa. The reaction mixture initially comprises of 25 mol% oxygen, 65 mol% nitrogen and the rest an inert gas. The standard Gibbs free energy change for the reaction is 113.83 kJ/mol at the given conditions. Calculate the partial pressures of all species in the equilibrium reaction mixture. Make suitable assumptions, if required. (10)

b. Derive the relation between conversion and extent of reaction. (4)

20. a. Estimate the equilibrium constant K_a at 1000K and 0.1 MPa for the reaction (14)

$$CO_2(g) + H_2(g) \rightarrow CO(g) + H_2O(g)$$

taking into account the variation of ΔH^0 with temperature.

Given: K_a at 298.15 is 8.685×10^{-6}

$C_p^0 = a + bT + cT^2 + dT^3 + eT^{-2}$, C_p^0 is in J/mol K and T is in K

Compound	a	$b \times 10^3$	c	d	$e \times 10^{-5}$
CO_2	45.369	8.688	-	-	-9.619
CO	28.068	4.631	-	-	-0.258
H_2O	28.850	12.055	-	-	1.006
H_2	27.012	3.509	-	-	0.690

Syllabus

Module 1

Scope of Thermodynamics, Thermodynamic Systems - closed, open and isolated system, intensive and extensive properties, path and state functions, reversible and irreversible process, Zeroth law of Thermodynamics, First Law of Thermodynamics - Energy Balance for Closed Systems, Limitations of First Law, Second Law of Thermodynamics – Carnot's principles - definition of entropy - calculation of entropy change in processes involving ideal gases, Third law of Thermodynamics, Energy balance of open systems - flow through pipe, nozzles, compressors.

Module 2

P-V and P-T diagram of pure substances, Equations of state for real gases - van der Waal's, Redlich Kwong, Peng Robinson and Virial equations, Principle of corresponding states and generalized compressibility chart, Fundamental property relations, Maxwell's Equations, Clausius-Clapeyron equation, Entropy-heat capacity relationships - equations for entropy, internal energy and enthalpy in terms of measurable quantities, Joule-Thomson coefficient, Gibbs Helmholtz equation, Fugacity and activity of pure fluids - selection of standard state, effect of temperature and pressure on fugacity and activity, Concept of Residual properties

Module 3

Definition of partial molar properties and chemical potential, Fugacity in solution, Ideal solution- Lewis-Randall rule - Raoult's law, Henry's law, Activity in solutions, Activity coefficient - effect of temperature and pressure on activity coefficient - Gibbs-Duhem equations, Property change of mixing, excess properties.

Criterion of phase equilibria - phase equilibrium in single component systems - phase equilibria in multicomponent systems - criterion of stability

Module 4

Phase rule for non-reacting systems, Duhem's theorem, Vapour-liquid equilibrium- phase diagram for binary solutions- VLE in ideal solutions- non-ideal solutions- positive and negative deviation- azeotropes- VLE at low pressures

Activity coefficient models - Wohl's equation - Margules equation - van Laar equation - Wilson equation - NRTL, UNIQUAC and UNIFAC models (General concepts only). Equations of VLE at high pressures. Definition of vaporisation equilibrium constant. bubble point, dew point and flash Calculations in multi component systems (derivations only). Phase diagrams of VLLE in partially miscible and immiscible.

Module 5

Chemical reaction equilibria - extent of reaction - equilibrium constant - standard free energy change - feasibility of reaction - effect of temperature on equilibrium constant – evaluation of equilibrium constant, Equilibrium conversion in gas-phase reactions, Effect of pressure and other parameters on conversion, Simultaneous reactions, Phase-rule for reacting systems

Text Books

1. Smith J. M. & Van Ness H.V., Introduction to Chemical Engineering Thermodynamics, 8th Edn, McGraw Hill, 2018.

2. Narayanan K. V., A Textbook of Chemical Engineering Thermodynamics, 2nd Edn., Prentice-Hall of India, 2013.

Reference Books

1. Stanley I. Sandler, Chemical and Engineering Thermodynamics, 2nd Edn., John Wiley & Sons,USA, 1989
2. Kyle B.G., Chemical and Process Thermodynamics, 3rd Edn, Prentice-Hall, 1999
3. Y.V.C. Rao, Chemical Engineering Thermodynamics, Universities Press, 1997
4. Milo D. Koretsky, Engineering and Chemical Thermodynamics, 2nd Edn, Wiley, 2012

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Scope of Thermodynamics (10 hours)**	
1.1	Thermodynamic Systems: Closed, open and isolated system, intensive and extensive properties, path and state functions, reversible and irreversible process	2
1.2	Laws of Thermodynamics: Zeroth law of Thermodynamics, First Law of Thermodynamics- Energy Balance for Closed Systems, Limitations of First Law	2
1.3	Second Law of Thermodynamics-Carnot's principles- definition of entropy-calculation of entropy change in processes involving ideal gases.	3
1.4	Third law of Thermodynamics, Energy balance of open systems-flow through pipe, nozzles, compressors.	3
2	**Thermodynamic properties (10 hours)**	
2.1	P-V and P-T diagram of pure substances,	1
2.2	Equations of state for real gases- van der Waal's, Redlich Kwong, Peng Robinson and Virial equations, Principle of corresponding states and generalized compressibility chart	2
2.3	Fundamental property relations, Maxwell's Equations, Clausius-	2

	Clapeyron equation, Entropy- heat capacity relationships-	
2.4	Equations for entropy, internal energy and enthalpy in terms of measurable quantities, Joule-Thomson coefficient, Gibbs Helmholtz equation,	2
2.5	Fugacity and activity of pure fluids- selection of standard state, effect of temperature and pressure on fugacity and activity, Concept of Residual properties	3
3	**Solution Thermodynamics (8 hours)**	
3.1	Definition of partial molar properties and chemical potential, Fugacity in solution.	2
3.2	Ideal solution- Lewis-Randall rule- Raoult's law, Henry's law, Activity in solutions, Activity coefficient- effect of temperature and pressure on activity coefficient- Gibbs-Duhem equations	3
3.3	Property change of mixing, excess properties. Criterion of phase equilibria - phase equilibrium in single component systems - phase equilibria in multicomponent systems - criterion of stability.	3
4	**Vapour-liquid equilibrium (9 hours)**	
4.1	Phase rule for non-reacting systems, Duhem's theorem.	1
4.2	Vapour-liquid equilibrium- phase diagram for binary solutions- VLE in ideal solutions.	1
4.3	non-ideal solutions- positive and negative deviation- azeotropes-	2
4.4	VLE at low pressures. Activity coefficient models- Wohl's equation- Margules equation- van Laar equation- Wilson equation- NRTL, UNIQUAC and UNIFAC models (General concepts only).	2
4.5	Equations of VLE at high pressures. Definition of vaporisation equilibrium constant, bubble point, dew point and flash calculations in multi component systems. Phase diagrams of VLLE in partially miscible and immiscible systems.	3
5	**Chemical reaction equilibria (8 hours)**	
5.1	Chemical reaction equilibria- extent of reaction- equilibrium constant - standard free energy change - feasibility of reaction -	2
5.2	Effect of temperature on equilibrium constant– evaluation of equilibrium constant,	2
5.3	Equilibrium conversion in gas-phase reactions, Effect of pressure and other parameters on conversion,	2
5.4	Simultaneous reactions, Phase-rule for reacting systems	2

CHT 204	HEAT TRANSFER OPERATIONS	CATEGORY	L	T	P	CREDIT
		PCC	3	1	0	4

Preamble:

This course includes the introduction of various modes of heat transfer. This course familiarizes the various steady and unsteady state conduction heat transfer situations. The determination of convective heat transfer coefficient in both forced and natural convection is included in this course. The laws of radiation and radiative heat flux are included in this course. The knowledge of various heat transfer mechanisms which are taught in this course is useful in the design and analysis of various heat transfer equipments like heat exchangers and evaporators. The heat transfer mechanism with phase change like boiling and condensation are also covered in this course.

Prerequisite: Basic knowledge in Engineering Science

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

CO 1	Identify and distinguish various modes of heat transfer and examine the mechanisms involved
CO 2	Apply appropriate governing equations and analyse conduction heat transfer problems for different geometries under steady state and transient processes
CO 3	Solve forced and natural convection heat transfer problems using empirical equations
CO 4	Explain the concepts behind radiation heat transfer and solve radiation heat transfer problems
CO 5	Analyse the heat transfer processes involved in boiling and condensation
CO 6	Design of heat exchangers and evaporators after interpreting the basic concepts

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	3		2								
CO 3	3	3		2								
CO 4	3	3		2								
CO 5	3	3										
CO 6	3	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): Identify and distinguish various modes of heat transfer and examine the mechanisms involved

1. Explain in detail the different modes of heat transfer?
2. A composite wall of a furnace is made of two materials A and B. The thermal conductivity of A is twice of that of B, while the thickness of layer A is half of that of B. If the temperature at the two sides of the wall are 400 and 1200K respectively, then determine the temperature drop across the layer of material A?
3. Explain the effect temperature on thermal conductivity. Write a note on thermal conductivity of solid, liquid and gas.

Course Outcome 1 (CO2): Apply appropriate governing equations and analyse conduction heat transfer problems for different geometries under steady state and transient processes

1. Derive the general conduction equation in Cartesian coordinates?
2. A furnace wall is made up of steel plate 10 mm thick (k=15 Kcal/hr m ^{o}C) lined on inside with silica bricks 150 mm thick (k= 1.75 kcal/hr m^{o}C) and on the outside with magnesia bricks 200 mm thick (k=4.5 kcal/hrm^{o}C). The inside and outside walls are at 650 ^{o}C and 125^{o}C resp. Calculate the resistance of the composite wall and the total heat loss through the wall?
3. Develop an equation for temperature profile for a lumped capacity system.

Course Outcome 2 (CO3) Make use of empirical equations to solve forced and natural convection heat transfer problems

1. Differentiate between natural and forced convection.
2. Explain the concept of boundary layer.
3. Calculate the heat transfer coefficient for a fluid flowing through a tube having inside diameter 40 mm at a rate of 5500 kg/h. Assume that the fluid is being heated. Properties of the fluid at mean bulk temperature are: μ = 0.004 kg/ms, ρ = 1.07 g/cc, Cp = 2.72 kJ/ kg K, k = 0.256 W/m K.

Course Outcome 3(CO4): Explain the concepts behind radiation heat transfer and solve radiation heat transfer problems

1. Define emissive power.
2. State and explain laws of radiation.
3. Derive the expression for net radiant energy exchange between two large parallel planes.

Course Outcome 4 (CO5): Analyse the heat transfer processes involved in boiling and condensation

1. Derive Nusselt's equation for film condensation on a vertical surface.
2. What is pool boiling? Explain various regimes of pool boiling.
3. Write down the Rohsenow correlation for boiling heat transfer.

Course Outcome 5 (CO6): Design of heat exchangers and evaporators after interpreting the basic concepts

1. How are heat exchangers classified?
2. Write down the material and energy balances for a single effect evaporator system.
3. A counter flow shell and tube heat exchanger is to be used to cool water from 27 ^{0}C to 6 ^{0}C using brine entering at -2 ^{0}C and leaving at 3 ^{0}C . The overall heat transfer coefficient is estimated to be 500 W/m^{2} ^{0}C. Calculate the heat transfer surface area for a design heat load of 10 kW.

Model Question Paper

QP CODE: PAGES: 2

Reg No:……_____
Name :……_____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
FIRST SEMESTER B. TECH DEGREE EXAMINATION,MONTH & YEAR
Course Code: CHT 204

Max Duration: 3 Hours Marks:100

HEAT TRANSFER OPERATIONS
(2019 Scheme)
PART A

(Answer all questions, each question carries 3 marks)

1. Define thermal conductivity and thermal diffusivity.
2. What is unsteady state conduction?
3. Explain boundary layer concept.
4. Briefly describe the factors that affect heat transfer coefficient.
5. State and explain Stefan-Boltzmann's Law of radiation.
6. Define saturation temperature.
7. What is LMTD correction factor?
8. What are compact heat exchangers?
9. Differentiate the terms capacity and economy.
10. Explain various evaporator auxiliaries.

PART B
(Answer one full question from each module, each question carries 14 marks)
Module -I

11. (a) Derive the expression for temperature profile and rate of heat transferred in a solid sphere. (8 marks)

    (b) A plane wall is 150 mm thick and its wall area is 4.5 m^2. If its thermal conductivity is 9.35W/mK and surface temperatures are steady at 150 ^{0}C and 50 ^{0}C, determine (a) the heat flow across the plane wall and the temperature gradient in the flow direction. (6 marks)

12. Derive the expression for unsteady state conduction using lumped capacity analysis (14 marks)

Module -II

13. Using dimensional analysis obtain the relation between Nu, Pr and Re in a forced convection system. (14 marks)

14. Develop the expression for Reynold's analogy between momentum and heat transfer. (14 marks)

Module -III

15. Derive the expression for net radiant energy transfer between two large parallel gray planes. (14 marks)

16. Using a neat diagram explain the different regimes of pool boiling. (14 marks)

Module -IV

17. Obtain the expression for LMTD in a counter flow heat exchanger. (14 marks)

18. a. Using a neat diagram describe the construction of a shell and tube heat exchanger. (8 marks)

b. A counter flow shell and tube heat exchanger is to be used to cool water from 27 ^{0} C to 6 ^{0} C using brine entering at -2 0 c and leaving at 3 ^{0} C. The overall heat transfer coefficient is estimated to be 500 W/m^2 ^{0} C. Calculate the heat transfer surface area for a design heat load of 10 kW. (6 marks)

Module -V

19. What are the different feeding arrangements for a multiple effect evaporator? Also Write the material and energy balance for a triple effect evaporator. (14 marks)

20. A single effect evaporator is fed with 5000 kg/h of solution containing 1 % solute by weight. The feed temperature is 303 K. It is to be concentrated to 2 % solute by weight. The evaporation is carried out at atmospheric pressure (101.325 kPa) and the area of the evaporator is 69 m^2 . Saturated steam is supplied at 143.3 kPa as a heating medium. Calculate the steam economy and the overall heat transfer coefficient.

Data : Enthalpy of feed at 303 K = 125 .79 kJ/kg
Enthalpy of vapour at 101.325 kPa = 2676.1 kJ/kg
Enthalpy of saturated steam at 143.3 kPa = 2691.5 kJ/kg
Saturation temperature of steam = 383 K
Boiling point of saturation = 373 K Enthalpy of product = 419.04 kJ/kg
Enthalpy of saturated water at 383 K = 461.30kJ/kg (14 marks)

Syllabus

Module 1 (Conduction)

Basic Concepts - Overview of applications of heat transfer in different fields of engineering, modes of heat transfer - conduction, convection and radiation, heat transfer with and without change of phase, material properties of importance in heat transfer - thermal conductivity, specific heat capacity, isotropic and anisotropic materials.
Conduction Heat Transfer - General heat conduction equation in cartesian coordinates(derivation required).
Formulation of heat transfer problems with and without generation of heat (uniform and non-uniform heat generation), one dimensional steady state heat conduction without generation of heat: Fourier heat conduction equation, thermal conductivity of solids, liquids and gases-comparison between them, effect of temperature on thermal conductivity, thermal diffusivity, conduction through systems of constant thermal conductivity - conduction through plane, cylindrical and spherical wall, combined boundary condition systems (conduction-convection systems), conduction through composite slab - multi-layered plane, cylindrical and spherical shells, electrical analogy to heat flow, numerical problems of practical importance based on the above topics.
Thermal insulation - Analysis of Critical radius of insulation for cylinders, optimum thickness of insulation, concept of optimum thickness of insulation, concept of thermal contact resistance, numerical problems based on the above aspects.
Unsteady State heat Conduction - Analysis of transient heat flow with negligible internal resistance-lumped capacity analysis, concept of Biot Modulus and Fourier number, Numerical problems of practical importance.

Module 2 (Convection)

Convection - Mechanism, boundary layer concepts, thermal and velocity boundary layers, boundary layer thickness, relationship between hydrodynamic and thermal boundary layer thickness for flow over flat plates, the convective heat transfer coefficient, reference temperatures, thermal boundary layers for the cases of flow over a flat plate and flow through pipe, dimensionless numbers in convective heat transfer and their significance.
Dimensional analysis - Rayleigh and Buckingham's pi theorem, its limitations, application of dimensional analysis to forced convection.
Forced Convection - General methods for estimation of convection heat transfer coefficient, correlation equations for heat transfer in laminar and turbulent flow for external and internal flows for constant heat flux and wall temperature conditions, flow in a circular tube (both developing and developed flows with constant wall temperature-its analysis and constant heat flux conditions) and non-circular tubes, flow over flat plates, flow over cylinder, spheres and tube banks, numerical problems of practical interest.
Natural Convection - Dimensional analysis, natural convection from vertical and horizontal surfaces under laminar and turbulent conditions for plates, cylinders under constant heat flux and wall temperature conditions, physical significance of Grashof and Rayleigh numbers, numerical problems of practical interest. Analogy between momentum and heat transfer- Reynold's analogy.

Module 3 (Radiation, Boiling and Condensation)

Heat transfer by radiation**:** Introduction- theories of radiation, electromagnetic spectrum, thermal radiation, spectral emissive power, surface emission, total emissive power, emissivity, radiative properties- Emission, irradiation, radiosity, absorptivity, reflectivity and transmissivity, concept of black and gray body, radiation intensity, laws of black body radiation, non-black surfaces, gray, white and real surface, radiation between black surfaces and gray surfaces, view factor, radiation between large parallel gray planes-derivation of expression for rate of radiant energy exchange, concentric cylinders and spheres (no derivation required), radiation between a small gray body and a large gray enclosure, radiation shields.
Boiling and Condensation - Dimensionless parameters in boiling and condensation, pool boiling, boiling curve, hysteresis in the boiling curve, mechanism of nucleate boiling, modes of pool boiling, pool boiling correlations, nucleate pool boiling correlations - Yamagata et al correlation, Rohsenow correlation, correlation for critical heat flux for nucleate pool boiling - Zuber correlation, condensation - physical mechanisms, types of condensation, factors affecting condensation, laminar film condensation on a vertical plate - detailed analysis by Nusselt to determine the heat transfer coefficient, drop wise condensation, comparison between dropwise and film type condensation, promoters and inhibitors used in condensation.

Module 4 (Heat Exchangers)

Classification of heat exchangers **- c**lassification according to transfer processes – Indirect contact heat exchangers, direct contact heat exchangers, classification according to number of fluids, classification according to surface compactness - gas-to-fluid exchangers, liquid-to-liquid and phase-change exchangers, classification according to construction features - tubular heat exchangers, plate-type heat exchangers, extended surface heat exchangers, regenerators, classification according to flow arrangements - single-pass exchangers, multi-pass exchangers, classification according to heat transfer mechanisms, basic construction of a shell and tube heat exchanger with details of the various parts, Concept of overall heat transfer coefficient - derivation of expression for overall heat transfer coefficient, Concept and types of fouling - fouling factors, determination of overall heat transfer coefficient with and without fouling, derivation of expression for LMTD, concept of logarithmic mean temperature difference and its correction factor, heat exchanger analysis using LMTD method in parallel flow, counter flow exchanger, cross flow and multi-pass heat exchangers, temperature – distance plots for different flow arrangements in single and multi-pass heat exchangers, NTU, determination of area, length, number of tubes required for a given duty in different configurations using LMTD and NTU method of analysis.

Module 5 (Evaporators)

Evaporation - Principle of evaporation, types of evaporators-their construction and operation - natural circulation evaporators, short tube vertical or calandria type evaporators, basket type vertical evaporators, long tube vertical evaporators, forced circulation evaporators, falling film evaporators, climbing or rising film evaporators, agitated thin film evaporators, plate evaporators, evaporator auxiliaries - vacuum devices, steam traps and its variants, entrainment separators, single effect and multiple effect evaporators, performance of evaporators, capacity and economy of evaporators, factors affecting the performance of evaporators, overall heat transfer coefficient, effect of liquid head and boiling point elevation, material and energy balances for single effect evaporator and the calculations on single effect evaporator, numerical problems of practical interest, temperature profile in evaporators.

Multiple effect evaporators - material and energy balance, temperature profile of liquids in the evaporator, enthalpy of solution, Different feeding arrangements in multiple effect evaporators – their merits and demerits.

Reference Books

1. Datta B.K., Heat Transfer: Principles and Applications, Prentice Hall India.
2. McCabe W.L., Smith J.C. & Harriott P., Unit Operations in Chemical Engineering, McGraw Hill.
3. Hollman J.P., Heat Transfer, McGraw Hill.
4. R C Sachdeva, Fundamentals of Engineering Heat and Mass Transfer, New age International Publishers.
5. M.Necati. Ozizik, Heat transfer - A basic Approach, McGraw-Hill College.
6. Coulson J.M. & Richardson J.F., Chemical Engineering, Vol. I and II, ELBS, Pergamon Press.
7. Kern D.Q., Process Heat Transfer, McGraw Hill.
8. Geankopolis C J, Transport Processes and Separation Process Principles, Prentice Hall of India, 4th Edition, Eastern Economy Edition (2004).
9. Incropera F P and DeWitt D P, Introduction to Heat Transfer, 2nd Ed John Wiley New York (1996).
10. Welty J.R., Engineering Heat Transfer, John Wiley.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Conduction (9 hours)**	
1.1	Basic Concepts**:** Overview of applications of heat transfer in different fields of engineering, modes of heat transfer- conduction, convection and radiation, heat transfer with and without change of phase. Material properties of importance in heat transfer, Thermal conductivity, Specific heat capacity, Isotropic and anisotropic materials.	1
1.2	Conduction Heat Transfer: General heat conduction equation in Cartesian coordinates (derivation is required). Formulation of heat transfer problems - with and without generation of heat (uniform and non-uniform heat generation) at steady and unsteady state.	2
1.3	One dimensional steady state heat conduction without generation of heat**:** Fourier heat conduction equation, thermal conductivity of solids, liquids and gases- comparison between them, effect of temperature on thermal conductivity; thermal diffusivity	1
1.4	Conduction through systems of constant thermal conductivity**: -** conduction through plane, cylindrical and spherical wall, combined boundary condition systems (conduction-convection systems), conduction through composite slab:-multilayered plane, cylindrical and spherical shells. Electrical analogy to heat flow. Numerical problems of practical importance based on the above topics.	2
1.5	Thermal insulation**:** Analysis of Critical radius of insulation for cylinders, optimum thickness of insulation. Concept of optimum thickness of insulation. Concept of thermal contact resistance	1

	Numerical problems based on the above aspects.	
1.6	Unsteady State heat Conduction**:** Analysis of transient heat flow with negligible internal resistance-lumped capacity analysis, concept of Biot Modulus and Fourier number-Numerical problems of practical importance.	2
2	**Convection (9 hours)**	
2.1	Convection**:** Mechanism, Boundary layer concepts - thermal and velocity boundary The convective heat transfer coefficient - reference temperatures, thermal boundary layers for the cases of flow over a flat plate and flow through pipe, dimensionless numbers in heat transfer and their significance	1
2.2	Dimensional analysis: Rayleigh and Buckingham's pi theorem, its limitations, application of dimensional analysis to forced convection.	2
2.3	Forced Convection: General methods for estimation of convection heat transfer coefficient, Correlation equations for heat transfer in laminar and turbulent flow for external and internal flows for constant heat flux and wall temperature conditions- flow in a circular tube (both developing and developed flows with constant wall temperature-its analysis and constant heat flux conditions) and non-circular tubes, flow over flat plates, flow over cylinder, spheres and tube banks. Numerical problems of practical interest	3
2.4	Natural Convection: Dimensional analysis**,** natural convection from vertical and horizontal surfaces under laminar and turbulent conditions for plates, cylinders under constant heat flux and wall temperature conditions, physical significance of Grashof and Rayleigh numbers. Numerical problems of practical interest.	2
2.5	Analogy between momentum and heat transfer**-** Development of Reynold's analogy.	1
3	**Radiation, Boiling and Condensation (8hours)**	
3.1	Heat transfer by radiation**:** Introduction- theories of radiation, electromagnetic spectrum, thermal radiation, spectral emissive power, surface emission- total emissive power, emissivity. Radiative properties- Emmision, irradiation, radiosity, absorptivity, reflectivity and transmissivity. Concept of black and grey body, radiation intensity, Laws of black body radiation, non-black surfaces- Grey, white and real surface, radiation between black surfaces and gray surfaces, view facor, radiation between large parallel gray planes-derivation of expression for rate of radiant energy exchange, concentric cylinders and spheres (no derivation required), radiation between a small gray body and a large gray enclosure. Radiation shields.	4
3.2	Boiling and Condensation: - Dimensionless parameters in boiling and condensation. Pool boiling - Boiling curve, hysteresis in the boiling curve, mechanism of nucleate boiling - modes of pool boiling, pool boiling correlations - Nucleate pool boiling - correlations - Yamagata et al correlation, Rohsenow correlation. Correlation for critical heat flux for nucleate pool boiling - Zuber correlation.	2
3.3	Condensation: Physical mechanisms, types of condensation, factors affecting condensation, laminar film condensation on a vertical plate - detailed analysis by Nusselt to determine the heat transfer	2

	coefficient. Dropwise condensation, Comparison between dropwise and film type condensation, promoters and inhibitors used in condensation.	
4	**Heat Exchangers (10 hours)**	
4.1	Classification of heat exchangers**:** Classification according to transfer processes: Indirect-Contact heat exchangers, direct-contact heat exchangers; Classification according to number of fluids; Classification according to surface compactness: gas-to-fluid exchangers, liquid-to-liquid and phase-change exchangers; Classification according to construction features: tubular heat exchangers, plate-type heat exchangers, extended surface heat exchangers, regenerators; Classification according to flow arrangements: single-pass exchangers, multi-pass exchangers; Classification according to heat transfer mechanisms.	2
4.2	Basic construction of a shell and tube heat exchanger with details of the various parts.	2
4.3	Factors affecting the selection of materials for engineering purposes selection of suitable materials for construction in chemical industry, Concept of overall heat transfer coefficient, Derivation of expression for overall heat transfer coefficient, Concept and types of fouling - fouling factors, determination of overall heat transfer coefficient with and without fouling.	2
4.4	Derivation of expression for LMTD Concept of logarithmic mean temperature difference and its correction factor - Heat exchanger analysis using LMTD method in parallel flow, counter flow exchanger, cross flow and multi-pass heat exchangers, Temperature – distance plots for different flow arrangements in single and multi-pass heat exchangers. NTU. Determination of area, length, number of tubes required for a given duty in different configurations using LMTD and NTU method of analysis.	4
5	**Evaporators (9 hours)**	
5.1	Evaporation: Principle of Evaporation, types of evaporators- their construction and operation-Natural circulation evaporators, short tube vertical or calandria type evaporators, basket type vertical evaporators, long tube vertical evaporators, forced circulation evaporators, falling film evaporators, climbing or rising film evaporators, agitated thin film evaporators, the plate evaporator. Evaporator auxiliaries - vacuum devices, steam traps and its variants, entrainment separators.	3
5.2	Single effect and multiple effect evaporators - Performance of evaporators, capacity and economy of evaporators, factors affecting the performance of evaporators. Overall heat transfer coefficient, effect of liquid head and boiling point elevation. Material and energy balances for single effect evaporator and the calculations on single effect evaporator. Numerical problems of practical interest. Temperature profile in evaporators	3
5.3	Multiple effect evaporators- temperature profile of liquids in the evaporator, enthalpy of solution, material and energy balance, Different feeding arrangements in multiple effect evaporators – their	3

	merits and demerits. .	

CHT 206	PARTICLE TECHNOLOGY	CATEGORY	L	T	P	CREDIT
		PCC	3	1	0	4

Preamble:

The importance of knowledge of the science of particulate materials (often called particle or powder technology) to the process industries cannot be over-emphasized. Very often, difficulties in the handling or processing powders are ignored or overlooked at the design stage, with the result that powder-related problems are the cause of an inordinate number of production stoppages. The topics included in the course are particle size analysis, storage and transport, and separation, size reduction operation, equipments used for size reduction and mixing. For each topic studied, the fundamental science involved is introduced and linked, where possible, to industrial practice.

Prerequisite: NIL

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

CO 1	Evaluate the particle size distribution, mean particle diameter, specific surface area and number of particles per unit mass using techniques such as sieve analysis, pipette analysis and beaker decantation	
CO 2	Identify the principles of free settling, hindered settling and mineral beneficiation techniques	
CO 3	Apply the concepts of filtration theory and select appropriate filtration equipment	
CO 4	Describe separation techniques for particulates in air	
CO 5	Select suitable size reduction equipment and estimate the energy requirements for a specified reduction in size for a given material.	
CO 6	Demonstrate mixing and conveying processes in chemical industries	

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											
CO 4	3											
CO 5			3									
CO 6	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 the functionality of a finite state machine and the microprocessor.

2. List the microprocessors launched by various company.

3. Define the functionality of a microprocessor.

Course Outcome 2 (CO2)

1. State the functionality of Program counter in a microprocessor

2. List the registers present in x86 microprocessors.

3. Define the functionality of a stack and stack pointer

Course Outcome 3(CO3):

1. Demonstrate the segment override instructions in x86

2. Give example for accessing content in the data segment

3. Describe the functionality of the branch instructions.

Course Outcome 4 (CO4):

1. Demonstrate the memory segmentation for x86 architecture.

2. Give example for generating physical address for accessing data segment.

3. Describe the functionality of the pipeline mechanism in X86

Course Outcome 5 (CO5):

1. Illustrate the accessing of data segment by various addressing mode.

2. Show the program for accessing a stack segment in x86

3. Demonstrate the operation of stack and stack pointer through push and pop Instructions.

Course Outcome 6 (CO6):

1. Illustrate that how to handle interrupts in x86 architecture

2. Show the program for accessing a maskable interrupt in x86

3. Demonstrate the operation of PPI -8252 with proper mapping diagram

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: CHT 206

Max. Marks: 100 Duration: 3 Hours

PARTICLE TECHNOLOGY

(2019-Scheme)

Part A

(Answer all questions, each question carries 3 marks)

1.How can the particle size distribution represented graphically? What are the advantages?

2.Which industrial screening equipment will you choose for handling sticky or clay like material? Discuss working of the equipment.

3.A mixture of quartz and galena of size range from 0.025mm to 0.075mm is to be separated into two pure fractions using hindered settling process. What minimum apparent density of the fluid that will give this seperation? The density of galena is 7500 kg/m^3 and the density of quartz is 2650 kg/m^3

4.Which mineral beneficiation technique is used in coal concentration on a wide range? With diagram explain the process.

5.What is the difference in choke feeding and free crushing?

6.In a ball mill of 2500 mm diameter, 150 mm diameter steel balls are used for grinding. The mill runs at 15 rpm. At what speed will the mill have to run if the 150 mm balls are replaced by 50 mm balls, all other conditions remaining the same?

7.Which filtration equipment is widely used in the laundries and pharmaceutical industries and can be made vapour tight for handling volatile materials? What are filtration equations associated with this equipment?

8.Name any one continuous filter equipment with general equation for the same.

9.List any three types of material handles in a screw conveyor

10.What are the factors for selection of a conveyor?

PART B

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

Module 1

11.a) Name and explain the working of the screen used for sizing the construction of gravel and crushed stone?

b) A particulate material has a density of 1.3 g/cc and sphericity of 0.6. The size analysis is as follows. Find the specific surface area and sauter diameter of the clay material

Average dia (cm)	0.0252	0.0178	0.0126	0.0089	0.00380
Mass fraction(g/g)	0.088	0.178	0.293	0.194	0.247

12.a) A sponge iron uses a vibrating screen of 5 mm aperture to separate oversize form the undersize fines which are recycled to the furnace. The screen analysis of the furnace output is found to contain 30% fines. The screen efficiency is 60%. Underflow from the screen contains 90% fines. If the furnace rate is 100 tonnes/h find the product rate and amount of fines present in it.

b) Explain any two methods of analysis of particles having size less than 40 microns?

Module 2

13a) What is the working of a rake classifier with figure?

b) Determine the cross sectional area of a continuous thickener to handle 100 tons/day of solids from an initial concentration of 236 g/lit to a final underflow concentration of 500 g/lit.

V_L(cm/hr)	2.08	2.40	4.375	7.86	11.6
C_L(g/cm^3)	0.462	0.443	0.386	0.303	0.266

14a) How the particle separation takes place by jigging?

b) Explain Kynch theory. Outline the procedure of a single batch sedimentation test to design a continuous thickener

Module 3

15a) What is the difference in choke feeding and free crushing?

b) In a ball mill of 2500 mm diameter, 150 mm diameter steel balls are used for grinding. The mill runs at 15 rpm. At what speed will the mill have to run if the 150 mm balls are replaced by 50 mm balls, all other conditions remaining the same?

16a) State and explain the different laws of size reduction with the importance of the work index in the size reduction.

b) With a neat sketch explain the working of fluid energy mills.

Module 4

17a) A sludge filtered in a washing plate and frame filter press is of such nature that the filtration equation is $V^2=Kt$ where V is the volume of filtrate obtained in time t, when pressure is constant.30 m^3 of filtrate is produced in 10 hours.3 m^3 of wash water is forced through the cake at the end of filtration. What is the length of the washing time?

b) What are steps of batch filtration cycle? Why batch filtration equipment's are generally operated at constant rate and then at constant pressure?

18a) Discuss the working of any pressure filter equipment.

b) Starting from the fundamentals, develop an expression to find filtration time required to recover a given volume of filtrate under constant pressure conditions

Module 5

19a) For the preparation of soup powder a mixture of dry vegetables and starch in a proportion of 30:70 is put to a batch mixer for blending. After 6 min the variance of the sample compositions measured in terms of fractional composition was 0.06. How long the mixing continue so as to reach specified maximum sample com position variance for a 50 particle sample 0.025? Assume the size of starch and dried vegetables to be almost equal.

b) What are the factors affecting the selection of a gas cleaning equipment?

20) a) What is the working of a venturi scrubber?

b) Write short note on (i) Banbury mixer and (ii) ribbon blender.

Syllabus

Module 1

Particle diameter and shape factor - particle size analysis - sieve analysis - particle size distribution - cumulative and differential methods of analysis - mean diameters - specific surface area and number of particles - screening - effectiveness and capacity of screens and factors affecting them - types of industrial screens-- sub-sieve analysis - pipette analysis - beaker decantation- elutriation

Module 2

Principles of free and hindered settling - equal settling particles - types of classifiers-mechanical and non-mechanical, pneumatic classifiers - principles of mineral benefication methods - jigging - wilfley table - froth flotation, principles, additives, batch and continuous thickening - Kynch theory - design of continuous thickener

Module 3

Laws of comminution - mechanism and efficiency of size reduction - principles of important size reduction equipments - types and selection of equipment for all ranges - closed circuit and open circuit grinding - free crushing and choke feeding - wet and dry grinding

Module 4

filtration - theory of constant pressure and constant rate filtration - cake porosity and compressibility - filter aids - optimum filtration cycle - types of batch and continuous filters (plate and frame, rotary, leaf filters-construction and working) -washing of filter cakes - centrifugal filtration (Top suspended basket centrifuge, reciprocating conveyor continuous centrifuge).

Module 5

Air separation methods - cyclone separation – electrostatic precipitation –Bag filters- venturi scrubber -Cottrell precipitator-. mixing of granular solids and pastes – mixing performance and effectiveness – mixers for noncohesive and cohesive solids - storage and conveying of solids (numerical problems are not required) - silos, bins and hoppers - different types of conveyors (Belt, chain, screw, pneumatic) - selection of conveyors.

Text Books

1. McCabe W.L., Smith J.C. and Harriot P., Unit Operations of Chemical Engineering McGraw Hill, New York 2001. 6th Edition
2. Anup K Swain, Hemlata Patra, G.K.Roy ,Mechanical Operations, Mc-Graw- Hill Education

Reference Books

1. Coulson J. M. and Richardson J.F; Chemical Engineering Vol. 1& 2 Publishers: Butter worth – Heinemann Ltd. 2001-2002.
3. Christie J. GeanKoplis, Transport processes & Unit Operation Prentice hall international
4. Badger & Banchero, Introduction to Chemical Engineering, Mc-Graw- Hill Education
5. C.M.Narayan,B.C.Bhattacharyya,Mechanical Operations for Chemical Engineers, Khanna publishers

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Module 1 (9 hr)**	
1.1	Particle diameter and shape factor.	1
1.2	particle size analysis - sieve analysis	1
	particle size distribution - cumulative and differential methods of analysis - mean diameters	1
1.3	types of industrial screens	2
1.4	specific surface area and number of particles	1
1.5	screening - effectiveness and capacity of screens and factors affecting them	2
1.6	sub-sieve analysis - pipette analysis - beaker decantation-elutriation	1
	Module 2 (9)	
2.1	Principles of free and hindered settling	1
2.2	equal settling particles	1
2.2	types of classifiers-mechanical and non-mechanical, pneumatic classifier	2
2.3	principles of mineral beneficiation methods	1
2.4	jigging - Wilfley table - froth flotation, principles, additives,	2

2.5	batch and continuous thickening - kynch theory - design of continuous thickener	2
3	**Module 3 (9 hr)**	
3.1	Laws of comminution	3
3.2	mechanism and efficiency of size reduction - principles of important size reduction equipment's	2
3.3	types and selection of equipment for all ranges	3
	Closed and open circuit grinding ,free crushing and choke feeding , wet and dry grinding	1
4	**Module 4 (9 hr)**	
4.1	filtration - theory of constant pressure and constant rate filtration	4
4.2	cake porosity and compressibility - filter aids - optimum filtration cycle -	1
4.3	types of batch and continuous filters (plate and frame, rotary, leaf filters-construction and working)	2
4.4	washing of filter cakes - centrifugal filtration (Top suspended basket centrifuge, reciprocating conveyor continuous centrifuge)	2
5	**Module 5 (9 hr)**	
5.1	Air separation methods-cyclone separation ,bag filter	1
5.2	Venturi scrubber -Cottrell precipitator	1
5.3	mixing of granular solids and pastes – mixing performance and effectiveness	2
5.4	mixers for noncohesive and cohesive solids	1
5.5	storage and conveying of solids(numerical problems are not required) - silos, bins and hoppers	2
5.6	different types of conveyors (Belt, chain, screw, pneumatic) - selection of conveyors.	2

CHL202	FLUID AND PARTICLE MECHANICS LAB	CATEGORY	L	T	P	CREDIT
		PCC	0	0	3	2

Preamble: The Fluid and Particle Mechanics lab is equipped with Centrifugal pump to transport fluid, flow measuring devices like Venturimeters, Orificemeters, Rotameters, and Weirs, etc. To study the fluid particle mechanics, flow through packed bed and fluidised bed can be carried out. The determination of viscosity of Newtonian and non-Newtonian fluid, pipeline assembling and layout drawing can be performed in the lab.

Prerequisite: Course in Fluid & Particle Mechanics

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

CO 1	Plan and perform experiments in flow measuring equipments and analyse the principles involved
CO 2	Plan and perform experiments in fluid moving machinery and analyse the principles involved
CO 3	Plan and perform experiments in solid-fluid systems and analyse the principles involved.
CO 4	Demonstrate capacity to work in teams and exhibit knowledge of safety, health and environment by practicing laboratory ethics.

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		
CO 3	3									3		
CO 4							3	3	3	3		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 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.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Perform experiments to analyse the influence of Reynolds number on the fluid flow
2. Perform experiments to verify Bernoulli's Theorem
3. Conduct experiments to establish the head-discharge relationship for venturimeter
4. Conduct experiments to establish the head-discharge relationship for orifice meter
5. Perform experiments to determine the coefficient of discharge Cd, coefficient of velocity Cv, and coefficient of contraction Cc of the given orifice, under constant head flow conditions.
6. Conduct experiments to establish hydraulic equation for weirs and notches.
7. Calibrate rotameter

Course Outcome 2 (CO2)

1. Study the performance characteristics of Centrifugal Pump and determine the maximum efficiency, optimum flow rate and head developed at maximum efficiency.

Course Outcome 3(CO3):

1. Perform experiments to determine the drag coefficient of a falling sphere in a fluid and verify Stoke's law.
2. Perform experiments to find the pressure drop of a liquid flowing through a packed bed and verify the Ergun equation.

3. Perform experiments to find the pressure drop in a liquid -solid fluidized bed and determine the entrainment velocity.

Course Outcome 4 (CO4):

1. Evaluate the experimentation capacity of student's in group.
2. Analyse the interpretation skill of results with group discussion.
3. Report experimental data, results within the stipulated time through team effort.

LIST OF EXPERIMENTS (Minimum of 8 mandatory)

1. Experiments on Reynolds apparatus for determination of flow regime and construction of fanning friction factor vs. Reynolds No. plot
2. Determination of co efficient of discharge for orifice meter
3. Determination of co efficient of discharge for venturimeter
4. Determination of co-efficient of Pitot tube and construction of velocity profile across the cross section of pipe.
5. Determination of co-efficient of discharge for different types of weirs.
6. Determination of pressure drop for flow through packed bed and verification of Ergun equation.
7. Experiment on fluidization techniques and determination of
   a) Minimum fluidization velocity;
   b) Pressure drop profile
8. Determination of efficiency of a centrifugal pump.
9. Pipe line assembling and a layout drawing with standard symbols.
10. Calibration of a Rotameter
11. Determination of viscosity of Newtonian & non-Newtonian fluid by Falling Sphere method
12. Verification of Bernoulli's Theorem
13. Determination of coefficient of discharge Cd, coefficient of velocity Cv, and coefficient of contraction Cc for open orifice.

Reference Books

1. McCabe W.L. & Smith J.C., Unit Operations of Chemical Engineering, McGraw Hill
2. Foust, Wenzel, Clump, Maus & Anderson, Principles of Unit Operation
3. R.K.Bansal, Fluid Mechanics and Hydraulic Machines

CHL 204	PARTICLE TECHNOLOGY LAB	CATEGORY	L	T	P	CREDIT
		PCC	0	0	3	2

Preamble: Operations related to size reduction, size separation, filtration, mixing, transportation and storage are important in many chemical and hydro-metallurgical industrial practices. This course aims to provide hands-on experience by conducting experiments on the basic mechanical operations (crushing, grinding, screening, filtration, etc.)

Prerequisite: CHT 206 Particle Technology

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

CO1	Use the basic principles of Particle technology to find solutions of problems by conducting experiments in the laboratory.
CO2	Design experiments and analyze/interpret data collected from experimental investigation in the laboratory
CO3	Use modern computing tools necessary for analysis of the experimental data in the laboratory.
CO4	Exhibit ethical principles in engineering profession by practicing ethical approaches in experimental investigation, collection and reporting of data and adhering to the safety ethics set by the laboratory
CO5	Practice work in diverse groups and perform laboratory experiments
CO6	Prepare cogent reports of the experimental works conducted in laboratory

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		3								
CO 3					3							
CO 4						3		3				
CO 5				2					3			
CO 6				2						3		

Assessment Pattern:
Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	75	75	2.5 hours

Continuous Internal Evaluation Pattern:

Attendance : 15 marks
Internal Assessment Test : 30 marks
Continuous evaluation Lab Performance : 30 marks

End Semester Examination Pattern:

The following guidelines should be followed regarding award of marks

(a) Preliminary work (Writing Principle and procedure) : 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.

Syllabus

List of Experiments:

Sl No.	Name of Experiment	No. of Hours
01	Sieve Analysis	3 Hrs
02	Effectiveness of Screen	3 Hrs
03	Laws of Crushing	3 Hrs
04	Sedimentation	3 Hrs
05	Pipette Analysis	3 Hrs
06	Beaker Decantation	3 Hrs
07	Free Settling – verification of Stoke's law	3 Hrs
08	Leaf Filter	3 Hrs

09	Cyclone Separator	3 Hrs
10	Plate & Frame Filter Press	3 Hrs
11	Study of equipments –I i. Rotary Drum Filter ii. Wilfley table iii. Belt Conveyor	3 Hrs
12	Study of Equipments-II i. Hammer Mill ii. Jaw Crusher iii. Ball Mill iv. Mineral Jig	3 Hrs

Reference books:

1. McCabe W.L., Smith J.C. and Harriot P., Unit Operations of Chemical Engineering McGraw Hill, New York 2001. 6th Edition
2. Coulson J. M. and Richardson J.F; Chemical Engineering Vol. 1& 2 Publishers: Butter worth – Heinemann Ltd. 2001-2002.
3. Christie J. GeanKoplis, Transport processes & Unit Operation Prentice hall international
4. Badger & Banchero, Introduction to Chemical Engineering, Mc-Graw- Hill Education

Details of course content:

Sl No.	Name of Experiment	Description of Experiment	No. of Hours
01	Sieve Analysis	Determination of particle size distribution, mean diameters, specific surface area and number of particles per unit mass	3 Hrs
02	Effectiveness of Screen	Determination of the effectiveness of the screen	3 Hrs
03	Laws of Crushing	verify the laws of crushing using a drop weight crusher and to find out the constants k_R, k_B and k_K and the work index to the given materials	3 Hrs
04	Sedimentation	Determination of area of a thickener.	3 Hrs

05	Pipette Analysis	Determination of particle size distribution, specific surface area and mean diameters.	3 Hrs
06	Beaker Decantation	Determination of particle size distribution, specific surface area and mean diameters.	3 Hrs
07	Free Settling	Verify Stokes law by plotting log C_d against logN_{Re}.	3 Hrs
08	Leaf Filter	Determination of specific cake resistance and compressibility factor.	3 Hrs
09	Cyclone Separator	Determination of collection efficiency.	3 Hrs
10	Plate & Frame Filter Press	Determine the specific cake resistance (α) and medium resistance (R).	3 Hrs
11	Study of equipments –I iv. Rotary Drum Filter v. Wilfley table vi. Belt Conveyor	To study the constructional details and working principle of equipments listed under study – I.	3 Hrs
12	Study of Equipments-II v. Hammer Mill vi. Jaw Crusher vii. Ball Mill viii. Mineral Jig	To study the constructional details and working principle of equipments listed under study – I.	3 Hrs

SEMESTER -4

MINOR

CHT 282	SAFETY ENGINEERING OF PROCESS PLANTS	CATEGORY	L	T	P	CREDIT
		VAC	4	0	0	4

Preamble: This course introduces students to the concepts of industrial safety, safety practices in industries and emergency procedures. It also outlines the various types of hazards and risk.

Prerequisite: Introduction to Chemical engineering

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

CO 1	Impart the basic concepts of safety in Process Industries.
CO 2	Apply engineering fundamentals on fire safety by fire prevention and flammability diagram.
CO 3	Identify various hazards associated with chemical process industries.
CO 4	Develop an understanding about safety practices in industries and emergency planning.
CO 5	Incorporate inherent safety, Hazard analysis techniques, and awareness about government agencies, regulatory bodies, codes, and standards that govern the global, societal, and environmental impact.

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
CO 2	3	3							2	2		2
CO 3	3	3								2		2
CO 4	3	3								2		2
CO 5	3	3								2		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): Impart the basic concepts of safety in Process Industries.

1. List the various site selection criteria for a safer industrial complex.

2. State key safety practices in an oil refinery

3. Define the components of a MSDS; demonstrate the need in updating its contents.

Course Outcome 2 (CO2): Apply engineering fundamentals on fire safety by fire prevention and flammability diagram.

1. List the classification of fire

2. Define fire pyramid and review its application in fire extinguishing

3. Describe BLEVE.

Course Outcome 3(CO3): Identify various hazards associated with chemical process industries.

1. List the physical hazards present in a process industry

2. Define the phenomenon of electric shocks and lightning stroke.

3. Describe health hazards due to chemical exposures

Course Outcome 4 (CO4): Develop an understanding about safety practices in industries and emergency planning.

1. List the safety procedures to be followed iin transportation of hazardous chemicals by road

2. Illustrate HAZCHEM CODE, TREM CARD

3. Describe the need of emergency planning in a process industry

Course Outcome 5 (CO5): Incorporate inherent safety, Hazard analysis techniques, and awareness about government agencies, regulatory bodies, codes, and standards that govern the global, societal, and environmental impact.

1. Illustrate safety audit procedures in a typical food processing industry

2. Describe Event tree analysis

3. List some salient features in Factories Act, Incorporating safety provisions.

Model Question paper

QP CODE: **Reg No:_____**

PAGES:3 **Name :_____**

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

Course Code: CHT 282

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

CHT 282 SAFETY ENGINEERING OF PROCESS PLANTS

(2019-Scheme)

PART A

(Answer all questions, each question carries 3 marks)

1. Write the significance of work permit systems.
2. Define accident.

3. What are the factors affecting the thermal runaway reaction.
4. Distinguish between Deflagration and detonation.
5. Differentiate between hazard and risk.
6. How will you quantify the radiation dose?
7. Write the significance of SIL.
8. Discuss the contents of TREM Card.
9. Differentiate between individual risk and societal risk.
10. What is probit equation? (10x3=30 marks)

PART B

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

MODULE I

11. a)What are the factors affecting the cost of accidents. Explain.

    b) Explain the major uses of MSDS. (10+4=14 marks)

12. a) What are the major reasons for Bhopal tragedy. Explain.

    b) Suggest a suitable plant layout for the Naphtha cracker unit. (8+6=14 marks)

MODULE II

13. What are the potential fire hazards in Petroleum and petrochemical industries? Explain (14 marks)
14. Explain in detail about the fixed fire protection system for a storage tank contains Naphtha. (14 marks)

MODULE III

15. a) Explain in detail about the lightning protection for a storage tank contain LPG.

    b) What are physical hazards? Discuss with suitable examples. (9+5=14 marks)

16. a) Discuss in detail about the health hazards due to Chemical exposure.

    b) What are the major consequences of explosion hazards? Explain. (7+7=14 marks)

MODULE IV

17.a) What are the statutory provisions leads to the preparation of Emergency plan.

b) Differentiate between onsite and offsite emergency plan. (7+7=14 marks)

18. a) An ammonia storage tank having a capacity of 10000 Tons situated at Eloor having a GPH_{tot} of 1.5, SPH_{tot} of 3.6. Calculate the Dow Fire & Explosive index and toxicity index of the installation. Also determine the hazardous category of the storage tank.

Data:-
Material factor of Ammonia = 6
NFPA index figure =3
MAC value = 20ppm (10 marks)

b) Safety integrity level is extremely important in process industry. Justify (4marks).

MODULE V

19.a) Explain the concept of inherent safety. Describe the various tools for assessing inherent process safety.
b) Explain the OR and AND gate rules with examples. (8+6=14 marks)

20.a) Develop a methodology for HAZOP technique as a tool for hazard identification.
b) Differentiate between individual risk and societal risk with examples.
(8+6 =14 marks)

Syllabus

Module 1

Introduction to safety: Concept and importance of industrial safety. Fundamental safety tenets. Safety in the site selection and lay out. Review of Industrial Accidents- Major Chemical Industry Accidents, Bhopal, Flixborough, SEVESO. Cost of accidents. Key safe practices in chemical industry for accident prevention programme. Material safety data sheet (MSDS)**.** Work permit system, Personal Protective Equipments (PPE).

Module 2

Fire & Safety: Classification of Fire- Pool fire, Jet fire, Flash fire, Explosion-UVCE, BLEVE, Dust explosion, Deflagration, Detonation. Toxic release, Runaway Reaction. Fire pyramid. Types of fire extinguishers and its handling. Fixed fire protection systems. Flammability diagram- construction,application.

Module 3

Hazards in a process industry: Chemical hazards- classification. Consequence of chemical hazards. Health hazards due to Chemical exposure, Physical hazards- Atmospheric contaminants, Sound, Light, Radiation, Pressure, and Temperature. Electrical hazards- electric shock, flash over, lightning Strokes. Mechanical hazards. Environmental hazards.

Module 4

Prevention techniques for hazards. Hazardous area classification. Safety in transportation of hazardous chemicals by road-HAZCHEM CODE, TREM CARD Relief system and Detectors. T.L.V, STEL, TLV-C, IDLH, UFL, LFL. Hazard rating of chemical plants- Dow index and Toxicity index. Emergency planning-onsite and offsite emergency planning, Mock drill.

Module 5

Safety analysis: Safety Inspections, safety Audits, safety Analysis, Hazard Survey and analysis, HAZOP, Bow tie diagram, Fault tree analysis, failure mode and effect analysis, Event tree analysis, examples. Quantitative Risk Assesment (QRA), Safety integrity level (SIL). Probit equations, FN curves, Risk-individual risk, societal risk. The concept of inherent safety. Occupational Health and Safety Administration**,** Safety provisions in Factories Act**.**

Reference Books

1. B. K. Bhaskara Rao, Er. R. K. Jain , Vineet Kumar, " Safety in Chemical Plants/Industry and Its Management", Khanna Publishers, First edition, 2010
2. R.K.Jain & Sunil S Rao, Industrial Safety, Health and Environment Management Systems, Khanna Publishers, Fourth Edition,2000
3. Encyclopaedia of Occupational Health & Safety, International labour Office, Geneva, 2012
4. Frank P. Lees- "Loss Prevention in Process Industries" ,Vol.1,2&3,Second Edn, Butterworth-Heinemann.1996
5. Guidelines for Hazard Evaluation Procedure. Centre for Chemical Process Safety.AICHE,1992
6. K.V. Raghavan and A. A. Khan : Methodologies in Hazard Identification and assessment Manual by CLRI, December 1990.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Introduction to safety**	
1.1	Concept and importance of industrial safety. Fundamental safety tenets. Safety in the site selection and lay out	3
1.2	Review of Industry Accidents Major Oil Industry Accidents Major Chemical Industry Accidents Cost of accidents.	2
1.3	Key safe practices in chemical industry for accident prevention	2

	programme.	
1.4	Material safety data sheet. Work permit system, , Personal Protective Equipments (PPE)	2
2	**Fire & Safety**	
2.1	Classification of Fire-Pool fire, Jet fire, Flash fire,	2
2.2	Explosion-UVCE, BLEVE, Toxic release, Runaway Reaction.	3
2.3	Fire pyramid. Types of fire extinguishers and its handling.	2
2.4	Fixed fire protection systems.	1
2.5	Flammability Diagram	1
3	**Hazards in a process industry:**	
3.1	Chemical hazards- classification. Consequence of chemical hazards. Health hazards due to Chemical exposure	3
3.2	Physical hazards- Atmospheric contaminants, Sound, Light, Radiation, Pressure, Temperature.	3
3.3	Electrical hazards- electric shock, flash over, lightning Strokes. Mechanical hazards.	2
3.4	Environmental hazards.	1
4	**Prevention techniques for hazards**	
4.1	Hazard area classification. Safety in transportation of hazardous chemicals by road	2
4.2	HAZCHEM CODE, TREM CARD Relief system and Detectors. T.L.V, STEL, TLV-C, IDLH, UFL, LFL.	3
4.3	Hazard rating of chemical plants- Dow index and Toxicity index. Safety integrity level (SIL).	2
4.4	Emergency planning-onsite and offsite emergency planning, Mock drill.	2
5	**Safety analysis**	
5.1	Safety Inspections, safety Audits, safety Analysis, Hazard Survey and analysis	2
5.2	HAZOP, Fault tree analysis, failure mode and effect analysis, Event tree analysis, examples. Probit equations, FN curves, Risk-individual risk, societal risk.	4
5.3	Occupational Health and Safety Administration, Safety provisions in Factories Act**.** The concept of inherent safety.	3

CHT 284	FUNDAMENTALS OF OIL AND NATURAL GAS ENGINEERING	CATEGORY	L	T	P	CREDIT
		VAC	3	1	0	4

Preamble:

This course introduce the students to the fundamentals of oil and natural gas engineering like the origin and formation of Petroleum,and petroleum geology.Students will get understanding about the various exploration techniques and well logging methods.The course provide an insight to oil well drilling and its completion. The course introduce the students to the fundamentals of oil and gas reservoir engineering. Also on the salient features of a gas reservoir. The course also introduce the students to geographic distribution of unconventional hydrocarbon resources and methodology to produce these reserves

Prerequisite: Nil

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

CO 1	Understand the fundamentals of petroleum geology and exploration.
CO 2	Summarize the basics of logging, drill and production techniques practiced in the oil wells.
CO 3	Apply the fundamental concepts in the oil and gas reservoir engineering.
CO 4	Outline the geology, origin, reservoir characteristics and production technology of unconventional oil.
CO 5	Demonstrate the geology, origin, reservoir characteristics and production technology of unconventional gases.

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					3
CO 2	3					3	3					3
CO 3	3	3				2	2					3
CO 4	3					2	2					3
CO 5	3					2	2					3
CO 6												

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	10
Understand	40	20	60
Apply		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): Understand the fundamentals of petroleum geology and exploration.

1. Outline the migration and accumulation of hydrocarbons from source rock to reservoir rock.
2. Classify various types of reservoir rocks.
3. Differentiate between absolute permeability and effective permeability.
4. Explain magnetic and seismic method for the exploration of petroleum

Course Outcome 2 (CO2): Summarize the basics of logging, drill and production techniques practiced in the oil wells.

1. Describe rotary drilling process for the crude oil production.
2. Outline the major function of packers in well completion. List any two packers.
3. List the main responsibility of mud-logging unit during the drilling of a well.
4. Explain main types of logs used in well logging

Course Outcome 3(CO3): Apply the fundamental concepts in the oil and gas reservoir engineering

1. Suppose that a vertical well produces 0.71 specific gravity gas through a 2.875 -in. tubing set to the top of a gas reservoir at a depth of 10,000 ft. At tubing head, the pressure is 800 psia and the temperature is 150 °F, whereas the bottom-hole temperature is 200 °F. The relative roughness of tubing is about 0.0006. Calculate the expected gas production rate of the well using the following data for IPR:

   Reservoir pressure = 2,000 psia

   IPR model parameter, C = 0.1 Mscf/d-psi^{2n}

   IPR model parameter, n = 0.8

2. The following data are available for a newly discovered gas reservoir:

   GWC = 9700 ft; Centroid depth = 9537 ft

   Net bulk volume (V) = 1.776 * 10^{10}cu.ft

   ϕ= 0.19; S_{wc} = 0 20; γ_g = 0.85

   Although a gas sample was collected during a brief production test the reservoir pressure was not recorded because of tool failure. It is known, however, that the water pressure regime in the locality is

   $$p_w = 0.441D + 31 \text{ psia}$$

   The temperature gradient is 1.258°F/100 ft, with ambient surface temperature80° F.

   a) Calculate the volume of the GIIP.

   b) It is intended to enter a gas sales contract in which the following points have been stipulated by the purchaser.

      1. During the first two years, a production rate build-up from zero – 100 MMscf/d (million) must be achieved while developing the field
      2. The plateau rate must be continued for 15 years at a sales point delivery pressure which corresponds to a minimum reservoir pressure of 1200 psia. Can this latter requirement be fulfilled? (Assume that the aquifer is small so that the depletion material balance equation can be used).

   c) Once the market requirement can no longer be satisfied the field rate will decline exponentially by 20% per annum until it is reduced to 20 MMscf/d.

(This gas will either be used as fuel in the company's operations or compressed to supply part of any current market requirement).

d) Determine the total recovery factor for the reservoir and the length of the entire project life.

Course Outcome 4 (CO4): Outline the geology, origin, reservoir characteristics and production technology of unconventional oil.

1. Explain Cyclic Steam Stimulation (CSS) and Steam-Assisted Gravity Drainage (SAGD) with neat figure
2. List the advantages and drawback of ex-situ retorting process for the shale oil production
3. Explain the formation of tar sand
4. Outline the composition of oil shales
5. Discuss various types of oil shales

Course Outcome 5 (CO5): Demonstrate the geology, origin, reservoir characteristics and production technology of unconventional gases.

1. Explain biogenic and thermogenic coal bed methane formation
2. Differentiate between shale gas and tight gas
3. Describe the structure of gas hydrates with a neat sketch
4. Differentiate depressurization and thermal stimulation for the production of gas hydrates
5. Describe hydraulic fracturing technique with a neat sketch for the production of shale gas

Model Question paper

QP CODE: PAGES: 3

Reg No: _____

Name: _____

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

Course Code: CHT 284

Max. Marks: 100 Duration: 3 Hours

FUNDAMENTALS OF OIL AND NATURAL GAS ENGINEERING

(2019-Scheme)

PART A

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

1 List the failures of inorganic theory.

2 Differentiate between absolute permeability and effective permeability.

3 List the main responsibility of mud-logging unit during the drilling of a well.

4 Outline the major function of packers in well completion. List two main types of packers.

5 Define reservoir deliverability and its significance.

6 Define recovery factor and its significance.

7 Explain the formation of tar sand.

8 Outline the composition of oil shales.

9 Explain biogenic and thermogenic coal bed methane formation.

10 Differentiate between shale gas and tight gas.

PART B

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

Module –I

11 Outline the migration and accumulation of hydrocarbons from source rock 14

to reservoir rock.

12	a	Classify various types of reservoir rocks.	6
12	b	Explain magnetic and seismic method for the exploration of petroleum.	8

Module – II

13		Describe rotary drilling process for the crude oil production.	14
14		Explain main types of logs used in well logging.	14

Module – III

15 The following data are available for a newly discovered gas reservoir: 14

GWC = 9700 ft ; Centroid depth = 9537 ft

Net bulk volume (V) = $1.776 * 10^{10}$cu.ft

$\phi = 0.19$; $S_{wc} = 0\ 20$; $\gamma_g = 0.85$

Although a gas sample was collected during a brief production test the reservoir pressure was not recorded because of tool failure. It is known, however, that the water pressure regime in the locality is

$$p_w = 0.441D + 31 \text{ psia}$$

The temperature gradient is 1.258°F/100 ft, with ambient surface temperature 80° F.

1. Calculate the volume of the GIIP.
2. It is intended to enter a gas sales contract in which the following points have been stipulated by the purchaser.
   ii) During the first two years, a production rate build-up from zero – 100 MMscf/d (million) must be achieved while developing the field
   iii) The plateau rate must be continued for 15 years at a sales point delivery pressure which corresponds to a minimum reservoir pressure of 1200 psia. Can this latter requirement be fulfilled? (Assume that the aquifer is small so that the depletion material balance equation can be used).
3. Once the market requirement can no longer be satisfied the field rate will decline exponentially by 20% per annum until it is reduced to 20 MMscf/d. (This gas will either be used as fuel in the company's operations or compressed to supply part of any current market requirement).
4. Determine the total recovery factor for the reservoir and the length of the entire project life.

16 Suppose that a vertical well produces 0.71 specific gravity gas through a 2.875 -in. tubing set to the top of a gas reservoir at a depth of 10,000 ft. At tubing head, the pressure is 800 psia and the temperature is 150 °F, whereas the bottom-hole temperature is 200 °F. The relative roughness of tubing is about 0.0006. Calculate the expected gas production rate of the well using the following data for IPR:

Reservoir pressure = 2,000 psia

IPR model parameter, C = 0.1 Mscf/d-psi^{2n}

IPR model parameter, n= 0.8

Module – IV

17	a	Discuss various types of oil shales.	6
17	b	List the advantages and drawback of ex-situ retorting process for the shale oil production.	8
18		Explain Cyclic Steam Stimulation (CSS) and Steam-Assisted Gravity Drainage (SAGD) with the help of a neat diagram.	14

Module – V

19		Describe hydraulic fracturing technique with a neat sketch for the production of shale gas.	14
20	a	Differentiate between the depressurization and the thermal stimulation for the production of gas hydrates.	10
20	b	Describe the structure of gas hydrates with a neat sketch.	4

Syllabus

Module 1: Fundamentals of petroleum geology and exploration

Introduction, origin, formation, geological occurrence and characteristics of oil and natural gas.Source Rocks, Reservoir Rocks, and Cap rocks: Definition, Characteristics, Classification and nomenclature, Concept of Shale oil,Reservoir Properties,Hydrocarbon migration,Petroleum Exploration.

Module 2: Introduction to well drilling and production

Well logging: Direct Methods: Mud logging- coring – conventional and sidewall coring - Core analysis.Concepts of well logging: Logging terminology-Borehole environment- Major components of well logging unit and logging setup- Classification of well logging methods. Well Drilling: cable tool drilling, rotary drilling, types of drilling units, and types of production units. Well completion, Production methods.

Module 3: Fundamentals of Oil and Gas Reservoir Engineering

Some basic concepts in reservoir engineering: Calculation of hydrocarbon volumes- Fluid pressure regimes- Oil recovery and recovery factor-Volumetric gas reservoir engineering-Gas material balance and recovery factor- Hydrocarbon phase behaviour.Reservoir deliverability: Flow regimes, IPR for various types of wells, well bore performance, Well deliverability, well decline analysis.

Module 4: Non-Conventional Oil

Shale oil: Introduction, geology, origin, types of oil shales, and occurrence worldwide, Kerogen and its composition, production technologies.Tar Sand: Introduction, geology, origin and occurrence worldwide, composition, resources, production technologies. Heavy oil: Introduction, geology, origin and occurrence worldwide, composition and production technologies.

Module 5: Non-conventional gas

Introduction, present status, formation and properties of coal bed methane, natural gas hydrate, tight gas sands, shale gas.Shale Gas: Exploration, Production-Drilling and completion.Natural Gas Hydrate: Concepts and Structures, Evaluation and Prediction, Production Techniques.

Reference Books

1. Elements of Petroleum Geology, Richard, C. Selley, Elsevier, 1997
2. Dake L. P., “Fundamentals of Reservoir Engineering”, Elsevier Science B. V, 1978
3. Manjooran S. K. B., “Modern Petroleum Chemistry”, Kannatheri Publication, 2004
4. Beggs D. H., “Gas Production Operations”, OGCI Publications, 1984

5. Petroleum Production Engineering: A Computer Assisted Approach, BoyunGuo, William C. Lyons, Ali Ghalambor, Elesevier Science & Technology Books, 2007.
6. James G. Speight,"Shale Oil Production Processes", Gulf Professional Publishing, 2012
7. Carrol John, "Natural Gas Hydrates: A guide for engineers", Gulf Professional Publishing, 2003
8. Rafiqul Islam, M., "Unconventional Gas Reservoirs: Evaluation, Appraisal, and Development", Gulf Professional Publishing, 2014

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Fundamentals of petroleum geology and exploration (8 hours)**	
1.1	Introduction, origin, formation, geological occurrence and characteristics of oil and natural gas.	1
1.2	Source Rocks: Definition of source rock, Organic rich sediments as source rocks, Nature and type of source rocks - Claystone / shale. Reservoir Rocks: Characteristics of Reservoir rocks, Classification and nomenclature: Sandstone Reservoir Rocks, Carbonate Reservoir Rocks, Unconventional, Fractured and Miscellaneous reservoir rocks, Marine and non-marine reservoir rocks, Concept of Shale oil.	1
1.3	Reservoir Properties and Cap Rocks: Reservoir pore space, porosity-primary and secondary porosity, effective porosity, fracture porosity - permeability – effective and relative permeability. Cap rocks: Definition and characteristics of cap rocks.	2
1.4	Hydrocarbon migration: Geological framework of migration and accumulation, The concept of hydrocarbon migration from source beds to the carrier beds, Carrier beds to the reservoir	2
1.5	Petroleum Exploration – gravimetric method, magnetic method, seismic method, borehole logging	2
2	**Introduction to well drilling and completion (9 hours)**	
2.1	Well logging: Direct Methods: Mud logging- coring – conventional and sidewall coring - Core analysis. Concepts of well logging: Logging terminology-Borehole environment-Major components of well logging unit and logging setup-Classification of well logging methods.	3
2.2	Well Drilling: cable tool drilling, rotary drilling, types of drilling units, types of production units	2
2.3	Well completion:Types of wells- Completion functions- Types of completion.	2
2.4	Production methods: water drive, gas cap drive, dissolved gas drive, artificial lift and enhanced oil recovery	2
3	**Fundamentals of oil and gas reservoir engineering (8 hours)**	
3.1	Some basic concepts in reservoir engineering: Calculation of hydrocarbon volumes- Fluid pressure regimes- Oil recovery and recovery factor-Volumetric gas reservoir engineering- Gas material balance and recovery factor- Hydrocarbon phase behaviour.	4

3.2	Reservoir deliverability: Flow regimes- transient, steady state, pseudo steady state, IPR for various types of wells, Well bore performance – single & multiphase liquid flow in oil wells, single phase & mist flow in gas wells; Well deliverability- nodal analysis, Well decline analysis.	4
4	**Non-Conventional Oil(10 hours)**	
4.1	Shale oil: Introduction, geology, origin, types of oil shales, and occurrence worldwide, Kerogen and its composition, production technologies – mining and retorting, Direct retorting –gas combustion retorting process and Lurgi-Ruhr gas process, In-situ retorting.	4
4.2	Tar Sand: Introduction, geology, origin and occurrence worldwide, composition, resources, production technologies – Ex-situ and In-situ process - Cyclic Steam Stimulation (CSS) and Steam-Assisted Gravity Drainage (SAGD).	4
4.4	Heavy oil: Introduction, geology, origin and occurrence worldwide, composition and production technologies.	2
5	**Non-conventional gas (10 hours)**	
5.1	Introduction, present statusof coal bed methane, natural gas hydrate, tight gas sands, shale gas.	2
5.2	Formation and properties of coal bed methane, natural gas hydrate, tight gas sands, shale gas.	2
5.3	Shale Gas: Exploration, Production-Drilling and completion.	3
5.4	Natural Gas Hydrate: Concepts and Structures, Evaluation and Prediction, Production Techniques.	3

CHT 286	MATERIAL SCIENCE AND ENGINEERING	CATEGORY	L	T	P	CREDIT
		VAC	3	1	0	4

Preamble:

Material Science is an interdisciplinary field. It deals with the design and discovery of new materials. Material science incorporates elements of physics, chemistry and engineering. The course deals with various aspects of material science such as atomic structure, properties of materials, selection of materials etc.

Prerequisite:

A basic course in physics and chemistry.

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

CO 1	Define qualitatively the structure and bonding schemes of solids.
CO 2	Explain physical properties and possible applications of a given material.
CO 3	Predict the stability of materials with all sorts of environments using phase diagrams.
CO 4	Identify and compare the properties of alloys, ceramics, polymers, composite materials and their engineering applications.
CO 5	Select suitable material for construction in chemical industries.
CO 6	Understand the properties and application of various smart materials

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											
CO 4	3											
CO 5	3											
CO 6	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): Define qualitatively the structure and bonding schemes of solids.

1. Define coordination number
2. Differentiate between crystalline and amorphous solids
3. Draw and explain the miller indices of unit cell of cubic crystal lattice

Course Outcome 2 (CO2) : Explain physical properties and possible applications of a given material.

1. Compare isotropy and anisotropy
2. Differentiate between ductility and malleability

3. Explain the technological properties of solid materials

Course Outcome 3(CO3): Predict the stability of materials with all sorts of environments using phase diagrams.

1. State and explain Hume Rothery rules
2. Draw and explain eutectic system with examples
3. Draw and explain Iron carbon diagram

Course Outcome 4 (CO4): Identify and compare the properties of alloys, ceramics, polymers, composite materials and their engineering applications.

1. Write a note on aluminium and its alloys
2. Classify ceramic and non-ceramic structures
3. List some materials used for high temperature applications

Course Outcome 5 (CO5): Select suitable material for construction in chemical industries

1. What are the factors affecting selection of materials for construction in chemical industry?
2. What are the factors affecting corrosion?
3. Explain aging of rubber

Course Outcome 6 (CO6): Understand the properties and application of various smart materials

1. What are nanomaterials?
2. Write a note on shape memory alloy
3. What are the applications of smart polymers?

Model Question Paper

QP CODE: PAGES:2

Reg No:_____

Name :_____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIRST SEMESTER B.TECH DEGREE EXAMINATION,MONTH & YEAR

Course Code: CHT 286

Max. Marks: 100

Duration: 3 Hours

MATERIAL SCIENCE AND ENGINEERING

(2019-Scheme)

PART A

(Answer all questions , each question carries 3 marks)

1. Distinguish between crystalline and amorphous solids
2. List three mechanical properties of materials and define them
3. Draw and explain Iron-Carbon diagram
4. State and explain Hume Rothery rules
5. Compare ceramic and non-ceramic structures
6. List some materials used for high temperature applications
7. What are corrosion inhibitors?
8. Explain aging of rubber
9. Define nanomaterials.
10. What are shape memory polymers?

PART B

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

Module -I

11. Describe the various bonding patterns in solids
12. (a) Describe stress-strain relationship using suitable diagram.

    (b) Define Poisson's ratio.

Module -II

13. What are solid solutions? Give an account of various types of solid solutions.

14. Distinguish between eutectic and peritectic systems using a phase diagram

Module -III

15. What are alloys?. Briefly describe aluminium and its alloys.

16. What are composite materials? Describe four applications of composite materials

Module -IV

17. Describe the mechanism and factors influencing corrosion

18. Explain the factors affecting the selection of materials.

Module -V

19. Explain in detail the history of nanotechnology.

20. Write a note on the properties and applications of smart polymers. (14x5 =70)

Syllabus

Module 1 (Crystal Structure and Properties of Engineering Materials)

Bonding in solids-Types of solids-crystalline and amorphous solids-crystal systems - Bravais lattices-miller indices-coordination number-crystal defects-determination of crystal structure-X-ray diffraction-electron diffraction methods.

Properties of engineering materials-mechanical properties -isotropy and anisotropy-elasticity, plasticity, toughness, resilience, tensile strength, ductility, malleability, brittleness, hardness, fatigue, creep, wear resistance- Poisson's ratio-stress-strain relation-true stress and true strain-electrical and magnetic properties-resistivity-conductivity-ionic and electrical conductivity, semiconductors, superconductivity, insulators, ferroelectricity, piezoelectricity, magnetization, paramagnetism, ferromagnetism, and diamagnetism -technological properties-castability, machinability, weldability, solderability, workability, formability.

Module 2 (Solid solutions)

Solid solutions-types of solid solutions-Hume Rothery rules-intermediate phases-mechanical

mixtures-phase diagrams-eutectic systems- peritectic system, eutectoid and peritectoid systems - carbon diagram-T-T-T diagram-plastic deformation-recrystallisation-hot and cold working of metals, Heat treatments-elementary study of various metals and alloys like cast iron,carbon steel,alloy steels.

Module 3 (Alloys and Composites)

Non-ferrous metals and alloys-aluminium and its alloys-copper and its alloys-Non ferrous metals and alloys used for high temperature services and nuclear application
Polymers and their properties-ceramics-classification-comparison of ceramic and non-ceramic structures-properties and application of ceramics Composite materials-classification-general characteristics.

Module 4 (Selection of Materials)

Corrosion-different types, mechanism and factors influencing corrosion-corrosion prevention-inhibitors and their applications-oxidation-aging of rubber-oxidation of metals and radiation damage-factors affecting the selection of materials for engineering purposes selection of suitable materials for construction in chemical industry.

Module 5 (Nano and Smart Materials)

(Only basic concepts of smart materials and nanomaterials are required) Introduction to nanomaterials – history, properties and applications. Introduction to smart materials Piezoelectric materials- piezoelectric effect, Piezoceramics, Piezopolymers Shape memory materials: Shape memory alloys (SMAs) and applications Smart polymers: Properties and Applications

Reference Books

1. Khanna O.P., A Text Book of Material Science & Metallurgy
2. Hajra Choudhary, Material Science & Processes
3. T. Pradeep, Nano: The Essentials, McGraw-Hill (India) Pvt Limited, 2008.
4. D.J. Leo, Engineering Analysis of Smart Material Systems, Wiley 2007.
5. Van Vlack, Elements of Material Science
6. Nanocomposite science and technology, Pulikel M. Ajayan, Wiley-VCH 2005

7. K. Otsuka, C.M. Wayman (Eds.), Shape Memory Materials, Cambridge University Press, 1998.
8. M.V. Gandhi, B. S. Thompson, Smart Materials and Structures, Chapman & Hall, 1992.
9. I. Galaev, B. Mattiasson (Eds.), Smart Polymers: Applications in Biotechnology and Biomedicine, 2nd ed., CRC Press, 2008.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Crystal Structure &Properties of Engineering Materials (10 hours)**	
1.1	Bonding in solids- Types of solids-crystalline and amorphous solids-crystal systems	1
1.2	Bravais lattices-miller indices-coordination number-crystal defects-determination of crystal structure-X-ray diffraction-electron diffraction methods	2
1.3	Mechanical properties -isotropy and anisotropy-elasticity, plasticity, toughness, resilience, tensile strength, ductility, malleability, brittleness, hardness, fatigue, creep, wear resistance	3
1.4	Poisson's ratio-stress-strain relation-true stress and true strain-electrical and magnetic properties-resistivity -conductivity-ionic and electrical conductivity, semiconductors, superconductivity, insulators	2
1.5	Ferroelectricity, piezoelectricity, magnetization, paramagnetism, ferromagnetism, and diamagnetism -technological properties-castability, machinability, weldability, solderability, workability, formability	2
2	**Solid Solutions (10 hours)**	
2.1	Solid solutions-types of solid solutions-Hume Rothery rules-intermediate phases-mechanical mixtures	1
2.2	Phase diagrams-eutectic systems-peritectic system	1
2.3	Eutectoid and peritectoid systems	1
2.4	Iron - carbon diagram-T-T-T diagram	3
2.5	Plastic deformation-recrystallisation-hot and cold	2

	working of metals,	
2.6	Heat treatments-elementary study of various metals and alloys like cast iron,carbon steel,alloy steels.	2
3	**Alloys and Composites (8 hours)**	
3.1	Non-ferrous metals and alloys-aluminium and its alloys-copper and its alloys	2
3.2	Non ferrous metals and alloys used for high temperature services and nuclear application	2
3.3	Organic polymers and its properties-ceramics-classification-comparison of ceramic and non-ceramic structures-	2
3.4	Properties and application of ceramics-composite materials-classification-general characteristics. Introduction to nanomaterials.	2
4	**Selection of Materials** (8 hours)	
4.1	Corrosion-different types, mechanism and factors influencing corrosion	2
4.2	Corrosion prevention-inhibitors and their applications-oxidation-aging of rubber-oxidation of metals and radiation damage	3
4.3	Factors affecting the selection of materials for engineering purposes selection of suitable materials for construction in chemical industry.	3
5	**Smart Materials (9 hours)**	
5.1	Introduction to nanomaterials – history, properties and applications.	3
5.2	Introduction to smart materials Piezoelectric materials- piezoelectric effect, Piezoceramics, Piezopolymers	2
5.3	Shape memory materials: Shape memory alloys (SMAs) and applications	2
5.4	Smart polymers: Properties and Applications	2

SEMESTER -4

HONOURS

CHT 294	INSTRUMENTAL METHODS FOR ENVIRONMENTAL ENGINEERING	CATEGORY	L	T	P	CREDIT
		VAC	3	1	0	4

Preamble:

The aim of the course is to deepen the students' knowledge of instrumental methods of chemical analysis to use them in environmental monitoring and remediation follow-up operations. The course will cover the areas such as sampling, measurement uncertainties, standards and reference materials, instruments for measuring various process variables, spectroscopic methods, separation methods etc.

Prerequisite: Nil

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

CO 1	Contrast on conventional vs. Experimental analytical methods used in environmental engineering.
CO 2	Choose among various instruments used for measuring different process variables.
CO 3	interpret results from laboratory tests, and analyse data and suggest remedies to common analytical problems encountered in the environmental engg
CO 4	to design experiments and conduct lab works pertinent to environmental analyses confidently, efficiently and in a safe manner.
CO 5	analyze waters and wastewaters for a wide range of advanced chemical characteristics like specific organic and inorganic contaminants, TOC,

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	2		2	3					
CO 2	3	3	3	2	2	2	3					
CO 3	3	3	3	3	3	3	3					
CO 4	3	3	3	3	3	2	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. List the application of solvent extraction
2. Illustrate the use of electrophoresis.
3. Distinguish between accuracy and precision with respect to measurements.

Course Outcome 2 (CO2)

1. Explain the use of sensors
2. Define sensibility and range of an instrument.
3. With neat sketch explain the working of any pressure measuring instrument..

Course Outcome 3(CO3):

1. Draw the figure of pH electrode and explain its working principle
2. Give the classification of spectroscopy methods and its application in various fields.
3. Write down the application, advantages and disadvantages of Ion Selective Electrode.
4. Differentiate between UV – Visible Spectrophotometer and Atomic Absorption Spectrophotometer.

Course Outcome 4 (CO4):

1. Give difference between visual & instrumental method of turbidity measurement.
2. Define terms NTU and FTU. Differentiate the terms Turbidimetry and Nephalometry
3. Explain the Gas chromatography with neat sketch.
4. Mention the classification of chromatography and write note on column chromatography

Course Outcome 5 (CO5):

1. What do you mean by online sensors?
2. Contrast on gas analysers used in industry.
3. Summarize the key factors to be considered while making the instrumentation and control system design of a wastewater treatment facility.

Model Question paper

QP CODE: CHT 294 **PAGES:3**

Reg No:_____ **Name :_____**

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

Course Code: CHT 294

Max. Marks: 100 Duration: 3 Hours

INSTRUMENTAL METHODS FOR ENVIRONMENTAL ENGINEERING (2019-Scheme) PART A

(Answer all questions, each question carries 3 marks)

1. List the application of solvent extraction.
2. What are the limitations of analytical methods
3. Differentiate the terms accuracy and precision.
4. Explain the working principle of conductivity meter with neat sketch.
5. List the commonly used optical methods of analysis.
6. Derive and explain Lambert's and Beer's law.
7. Give difference between visual & instrumental method of turbidity measurement.
8. Give the classification of chromatographic methods and application in various fields.
9. What is Advanced Environmental Instrumentation? Give its significance in environmental engineering field.
10. Write about the instruments used for particulate matter monitoring. (10*3=30)

PART B

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

Module I

11. (a) Write a short note on "Laboratory Errors and its types"
    (b) With suitable examples, explain analytical instruments and process instruments
12. (a) Define the types of determinate errors with at least one example of each
    (b)What are the various chemical, and biological methods used in environmental engineering.

Module II

13. (a) Explain the characteristics of a good measuring instruments
    (b) With the help of neat sketch explain components of Ion Selective electrode.

14. (a) Give the significance of DO in environment and explain in details of DO probe (electrode).
    (b) Explain the measurement of PH by potentiometry and discuss the advantages.

Module III

15. (a) Enlist the types of Detectors used in Spectroscopy. Explain Flame Ionization Detector in detail.
    (b) State the Principle of IR Spectroscopy with its instrumentation and neat sketch.

16. (a) Explain the principle, instrumentation and applications of AAS.
    (b) How X-rays are produced and detected by X-ray diffraction?

Module IV

17. (a) Define terms NTU and FTU. Differentiate the terms Turbidimetry and Nephalometry with proper diagrams.
    (b) Discuss briefly the principle, apparatus used and its working and advantages of HPLC.
18. (a) Discuss about the various radioactivity methods used for pollutant charecterisation.
    (b) Explain the Column chromatography with neat sketch.

Module V

19. (a) Write in detail about the different gas analyzers used in industry
    (b) Discuss about process instrumentation and control in lab and pilot experiments.
20. (a) Discuss about water pollution control instrumentation.
    (b) Explain in detail about the basic design concepts for instrumentation and control for wastewater treatment process.

Syllabus

Module 1

Basic Principles, Instrumentation and application of solvent extraction, ion exchange, electrophoresis, Limitations of analytical methods Accuracy and precision classification and minimization of errors. Instrumental methods in environmental engineering, analytical methods, chemical, instrumental and biological methods. Analytical instruments and process instruments.

Module 2

Sensors, body of the instrument, read out, accuracy, precision, sensibility, range, resolution, caliberation. Transducers- measurement of nonelectrical quantities like pressure temperature, displacement, velocity, acceleration etc. strain gauge and its applications, use of microprocessors in instrumentation. Potentiometer: pHmeter,ionselectiveelectrodes,redoxpotential.Polarographicanalysis, photometry, DO meter, conductivty, coulometry and its applications.

Module 3

Optical methods of analysis:absorption and emission methods, interaction of radiation with different types of molecular energy Basic principles, Instrumentation and Applications of visible spectrum photometer, Spectrophotometry- U.V. Spectrometer,infraredspectrometer,flame photometer, atomic absorption spectrophotometer.X-ray diffraction method, massspectrometer,methods using microscopy,refractrometric method

Module 4

Dispersion and scattering: turbidimetry and nephelometry, fluorimetry. Thermal conductivity method ,radioactivity methods, sound absorption method.

Chromatography: general principles and specific techniques-thin layer, column, liquid, high performance, ion etc

Module 5

Air and water pollution control instrumentation, computer aided analysis, process instrumentation and control in lab and pilot experiments. Process Control Instrumentation: basic design concepts for air ,water and waste water treatment process instrumentation

Text Books/

Reference Books

1. Sawyer and McCarty-Chemistry for environmental engineering, Tata McGraw Hill
2. Kemmer-The NALCO Water Handbook, Tata McGraw Hill
3. Keith A Smith, Malcalm S Cressar, Soil & Environment Analysis, Modern

Instrumental Techniques, Marcel Dekker, inc.
4. D.A. Skoog, D.M. West and T.A. Nieman, Principles of Instrumental Analysis,5th Ed. Thomson Asion (P) Ltd. Singapore, 2004
5. H.H, Willard, L.L. Merit, J.A. Dean and F.A. Settle, Instrumental Methods of Analysis, 7th Ed. CBP Publishers and Distributors, New Delhi, 1986
6. Daniel C Harris, Quantitative chemical analysis, 8th edn (2011)
7. Prdyot Patnaik, Hand book of environmental analysis: chemical pollutants in air, water soil and solid wastes, 2nd edn.
8. Principles of instrumental analysis, 6th edn Skog, Holler and Nieman

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Module 1 (8 hrs)**	
1.1	Basic Principles, Instrumentation and application of solvent extraction, ion exchange, electrophoresis, Limitations of analytical methods. Accuracy and precision classification and minimization of errors.	4
1.2	Instrumental methods in environmental engineering, analytical methods, chemical, instrumental and biological methods.	2
1.3	Analytical instruments and process instruments.	2
2	**Module 2 (8 hrs)**	
2.1	Sensors, body of the instrument, read out, accuracy, precision, sensibility, range, resolution.Transducers.	3
2.2	Measurement of nonelectrical quantities like pressure, temperature, displacement, velocity, acceleration etc.	3
2.3	Strain gauge and its applications, use of microprocessors in instrumentation.	2
3	**Module 3 (10 hrs)**	
3.1	Potentiometer: pH meter, ion selective electrodes, redox potential. Polarographic analysis, photometry, DO meter, conductivty, coulometry and its applications	3
3.2	Optical methods of analysis: absorption and emission methods, interaction of radiation with different types of molecular energy	3
3.3	Basic principles, Instrumentation and Applications of visible spectrum photometer, Spectrophotometry- U.V. Spectrometer, infrared spectrometer, flame photometer, atomic absorption spectrophotometer.	4
4	**Module 4 (10 hrs)**	
4.1	X-ray diffraction method, mass spectrometer, methods using microscopy, refractometric method.	3
4.2	Dispersion and scattering: turbidimetry and nephelometry, fluorimetry.	2
4.3	Thermal conductivity method, radioactivity methods, sounds absorption method.	2
	Chromatography: general principles and specific techniques-thin	3

	layer, column, liquid, high performance, ion etc.	
5	**Industrial Effluent Treatment –II (9 hrs)**	
5.1	Air and water pollution control instrumentation, computer aided analysis.	3
5.2	Process instrumentation and control in lab and pilot experiments.	3
5.3	Process Control Instrumentation: basic design concepts for air, water and waste water treatment process instrumentation	3

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
KTU
Estd. 2014

CHT 296	MODERN METHODS OF INSTRUMENTATION	CATEGORY	L	T	P	CREDIT
		VAC	4	0	0	4

Preamble: This course introduces students to some modern ideas and tools used for measuring variables in a process industry which are essential for proper control and functioning of all equipments and processes. The idea of measurement instrumentation traces its way long back from history of human development and finds application in all walks of development like research, design, product development and process industries.

Prerequisite: Basic concepts of process instrumentation

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

CO 1	Understand the basic principles of measurement instrumentation and characterize instruments based on their performance characteristics
CO 2	Explain and sketch various measuring instruments used for temperature measurement and their safe application.
CO 3	Characterize and sketch various measuring instruments used for level and pressure in process industries.
CO 4	Apply measurement instrumentation for flow measuring in various applications
CO 5	Familiarize modern method of instrumentation for composition analysis, humidity and moisture content measurement
CO 6	Analyze P&ID Diagrams for process industries with regards to instrumentation.

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									
CO 2	3		1			1	1					
CO 3	3		1									
CO 4	3		1									
CO 5	3		1									
CO 6	3	3	3							1		

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	10

Understand	20	20	30
Apply	20	20	60
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):

What you mean by sensitivity of an instrument

Course Outcome 2 (CO2)

Classify different temperature measuring instruments

Course Outcome 3(CO3):

Suggest a method for the measurement of pressure above 10,000kg/cm^2 . write its working principle

Course Outcome 4 (CO4):

List the advantages & limitations of magnetic flow meter?

Course Outcome 5 (CO5):

Explain working principle of XRD

Course Outcome 6 (CO6):

Draw P&ID diagram for shell & tube heat exchanger

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: CHT 296

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

MODERN METHODS OF INSTRUMENTATION

(2019-Scheme)
PART A
(Answer all questions, each question carries 3 marks)

1. Differentiate accuracy & Precision of an instrument.
2.Give any 3 examples for indirect measurement.
3.write the temperature range of mercuric thermometer & radiation pyrometer.
4.list out the different types of errors occur in temperature measurement.
5.suggest any 2 instruments each for low, medium and high pressure measurement
6.what are the different solid level detectors.
7.what are head meters? Give examples.
8.explain the principle of hygrometer
9.draw the P & ID diagrams for a). pump b) valve
10.What is the principle of thermogravimetric analysis.

PART B

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

Module I

11. a) With an example explain the functional elements of an instrument. (8)

b) Explain static characteristics of instruments.(6)

12. a) Explain dynamic characteristics of instruments. (8)

b) Explain different class of instruments. (6)

Module II

13. a)List the different expansion based thermometers. Explain with examples and sketch for each.(9)

b)With a neat sketch explain the working principle of optical pyrometer. (5)

14). a) Explain Temperature measurement with thermistor and RTD. (9)

b).What are the sources of errors in temperature measurement. List the precautions.(5)

Module III

16).a) List different types of manometers. With neat sketch explain (8)

b).Explain the working of Kenetometer. write the advantages & limitations.(6)

17). a) Explain pressure measurement in corrosive liquids. (5)

b).Explain different level measurement techniques.(9)

Module IV

18). a) What are open channel flow meters. Explain. (5)

b).Differentiate variable area and variable head meters with examples for each.(9)

19). a) with a neat sketch Explain the working ultrasonic flow meter. (7)

b).what is the importance of moisture content determination of materials. What are the available techniques. 7)

Module V

20). a) Explain mass spectroscopy. (9)

b).What is the importance of P & ID diagrams? draw P & Id diagram for level control system.(5)

21). a) Explain Gas analysis by chromatography. (9)

b).What is the principle of thermogravimetric analysis.(5)

Syllabus

Module 1 (8 Hours)

Introduction-definition of instrumentation-concept of an instrument Basic principles of measurements - Classification of methods of measurements - Direct and indirect measurements, various elements in a measuring instrument - Sensing element, transducing element manipulating element and functioning element etc- Principles and working of an instrument with a suitable example, static and dynamic characteristics of measuring instrument, accuracy, reproducibility, sensitivity, static error, dead zone, dynamic error, fidelity lag, speed of response etc.

Module 2 (8 Hours)

Temperature measurements, temperature scales, basic principles and working of thermometers, mercury in glass thermometers, bimetallic thermometers, resistance thermometers, thermocouples, thermistors, resistance thermal detectors (RTD) optical pyrometers, radiation pyrometers.
Ranges of different types of temperature measuring instruments, sources of errors and precautions to be taken in temperature measurements.

Module 3 (10 Hours)

Pressure measurement - Principles of working of manometers, various types of manometers. Medium industrial pressure measurement by Bourdon gauge, bellows, diaphragm, electrical pressure transducers, strain gauges and piezoelectric manometers Low pressure measurement by thermal conductivity gauge, ionization gauge, radioactive vacuum gauge. High pressure measuring instruments- air pressure balance method.
Pressure measurement of corrosive liquids. Level measurement-direct type and indirect type. Differential pressure method for pressurized vessels. Conductivity meters. Solid level detectors.

Module 4 (9 Hours)

Flow measurements: magnetic flow meters, turbine meters, open channel flow measurements by wires & notches, head meters, pitot tube, orifice meters venturi meters, quantity meters, gas meters, magnetic flow meters, heat input flow meters, elbow flow meters, impact meters, variable area meters like rotameters, measuring flow of dry materials by mass flow meters.
Moisture content determination by thermal drying. Instruments for measuring humidity like hygrometer, psychrometer, dew point apparatus.

Module 5 (10 Hours)

Composition analysis using spectroscopic methods like absorption, emission and mass spectrometers. Analysis of solids by X-ray diffraction. Gas analysis by thermal conductivity, polarography & chromatography.
pH measurement using calomel electrode. Thermo gravimetric analysis, Differential Scanning calorimetry P & ID symbols. Analysis of P&ID for flow systems, level control,

pressure control, temperature control, heat exchangers, distillation column and reaction system.

Reference Books

1. Jain R K, Mechanical and Industrial measurements, Khanna publishers
2. Patranabis D, Principles of Industrial Instrumentation, Tata- McGraw Hill.
3. Ernest O Doeblin, Measurement systems, Application and Design, McGraw Hill
4. Donald P Eckman, Industrial Instrumentation, CBS Publishers and Distributors, New Delhi

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Module I (8 hr)**	
1.1	Introduction-definition of instrumentation-concept of an instrument	1
1.2	Basic principles of measurements, Classification of methods of measurements - Direct and indirect measurements	1
1.3	various elements in a measuring instrument - Sensing element, transducing element manipulating element and functioning element	1
1.4	Principles and working of an instrument with a suitable example	1
1.5	Static characteristics of measuring instrument, accuracy, reproducibility,	1
1.6	sensitivity, static error, dead zone	1
1.7	and dynamic , dynamic error, fidelity lag, speed of response	1
1.8	Problems based on performance characteristics	1
2	**Module II (8 hr)**	
2.1	Temperature measurements, temperature scales	1
2.2	basic principles and working of thermometers, mercury in glass thermometers	1
2.3	bimetallic thermometers	1
2.4	thermocouples and thermoelectricity	1
2.5	thermistors, resistance thermal detectors (RTD)	1
2.6	optical pyrometers, radiation pyrometers.	1
2.7	Ranges of different types of temperature measuring instruments	1
2.8	sources of errors and precautions to be taken in temperature measurements	1
3	**Module III (10 hr)**	
3.1	Pressure measurement - Principles of working of manometers, various types of manometers. ,	2

3.2	Medium industrial pressure measurement by Bourdon gauge, bellows, diaphragm	2
3.3	electrical pressure transducers, strain gauges and piezoelectric manometers	1
3.4	Low pressure measurement by thermal conductivity gauge, ionization gauge, radioactive vacuum gauge.	2
3.5	High pressure measuring instruments- air pressure balance method.	1
3.6	Level measurement-direct type and indirect type. Differential pressure method for pressurized vessels	1
3.7	Pressure measurement of corrosive liquids. . Conductivity meters. Solid level detectors	1
4	**Module IV (9 hr)**	
4.1	Flow measurements: magnetic flow meters, turbine meters	1
4.2	open channel flow measurements by wires & notches	1
4.3	head meters, pitot tube, orifice meters venturi meters,	2
4.4	quantity meters, gas meters	1
4.5	magnetic flow meters, heat input flow meters, elbow flow meters, impact meters	1
4.6	variable area meters like rotameters, measuring flow of dry materials by mass flow meters.	1
4.7	Moisture content determination by thermal drying	1
4.8	Instruments for measuring humidity like hygrometer, psychrometer, dew point apparatus.	1
5	**Module V (10 hr)**	
5.1	Composition analysis using spectroscopic methods like absorption, emission and mass spectrometers... ,	2
5.2	Analysis of solids by X-ray diffraction	1
5.3	Gas analysis by thermal conductivity, polarography & chromatography	2
5.4	pH measurement using calomel electrode. Thermo gravimetric analysis, Differential Scanning calorimetry	1
5.5	P & ID symbols.Developments of P&I, diagram for flow systems	1
5.6	P & ID diagram for level control, pH control, temperature control	1
5.7	P & ID diagram for Heat exchangers, Distillation column and reaction system	2

CHT292	COMPUTATIONAL METHODS IN CHEMICAL ENGINEERING	CATEGORY	L	T	P	CREDIT
		VAC	3	1	0	4

Preamble:

Numerical Methods use computers to solve problems by step-wise, repeated and iterative solution methods, which would otherwise be tedious or unsolvable by hand-calculations. This course is designed to give an overview of numerical methods of interest to scientists and engineers. The course aims at giving adequate exposure to methods for numerically solving algebraic and transcendental equations, system of linear and non linear equations, polynomial interpolation, differential and partial differential equations.

Prerequisite: Nil

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

CO 1	Identify the errors, source of error and its effect on any numerical computations
CO 2	Solve polynomial and transcendental equation using an appropriate numerical method
CO 3	Solve linear and non-linear algebraic system of equations using an appropriate numerical method
CO 4	Apply different numerical methods for interpolation, differentiation and integration of functions and analyze errors.
CO 5	Solve ordinary differential equations by different numerical methods.
CO 6	Solve elliptic, parabolic, and hyperbolic partial differential equations using finite difference methods

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
CO 2	3	3			3					2		3
CO 3	3	3			3					2		3
CO 4	3	3			3					2		3
CO 5	3	3			3					2		3
CO 6	3	3			3					2		3

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember			
Understand	10	10	20

Apply	40	40	80
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): Identify the errors, source of error and its effect on any numerical computations.

- If $z = (xy^3)/8$, find the percentage error in 'z' when $x = 3.14 \pm 0.0016$ and $y = 4.5 \pm 0.05$

Course Outcome 2 (CO2): Solve polynomial and transcendental equation using an appropriate numerical method.

- Air at 25°C and 1 atm flows through a 4 mm diameter tube with an average velocity of 50 m/s. The roughness is ε = 0.0015 mm. Develop a MATLAB program based on Newton – Raphson method to determine the friction factor using the Colebrook equation.

  $$\frac{1}{f} = -2.0\ log\left(\frac{\varepsilon/D}{3.7} + \frac{2.51}{R_e\sqrt{f}}\right)$$

  Determine the pressure drop in a 1 m section of the tube using the relation

  $$\Delta P = \frac{fL\bar{V}\rho}{2D}$$

  Density of the air at 25°C and 1 atm is 1.23 kg/m^3 and the viscosity is 1.79 X 10^{-5} kg/ms.

Course Outcome 3(CO3): Solve linear and non-linear algebraic system of equations using an appropriate numerical method.

- Apply Gauss – Jordan method to solve the equations using C++

$$x + y + z = 9$$
$$2x - 3y + 4z = 13$$
$$3x + 4y + 5z = 40$$

Course Outcome 4 (CO4): Apply different numerical methods for interpolation, differentiation and integration of functions and analyze errors.

- The following data gives the melting point of an alloy of lead and zinc, where t is the temperature in ^{0}C and P is the percentage of lead in the alloy:

p	40	50	60	70	80	90
t	184	204	226	250	276	304

With the help of Excel program using Newton's interpolation formula, find the melting point of the alloy containing 84 percent of lead.

Course Outcome 5 (CO5): Solve ordinary differential equations by different numerical methods.

- The concentration of salt x in a homemade soap maker is given as a function of time by

$$\frac{dx}{dt} = 37.5 - 3.5x$$

At the initial time, t = 0, the salt concentration in the tank is 50 g/L develop a MATLAB program using Runge-Kutta 4th order method and a step size of, h = 0.75 min, determine the salt concentration after 3 minutes.

Course Outcome 6 (CO6): Solve elliptic, parabolic, and hyperbolic partial differential equations using finite difference methods

- Solve the equation below subject to the initial condition u(x, y, 0) = sin 2πx sin 2πy, 0 ≤ x, y ≤ 1, and the conditions u(x, y, t) = 0, t > 0 on the boundaries.

$$\frac{\partial u}{\partial t} = \frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2}$$

Obtain the solution up to three time level with h = 1/3 and α = 1/8 by writing a program in MATLAB

Model Question paper

QP CODE: PAGES: 3

Reg No: _____

Name: _____

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

Course Code: CHT 292

Max. Marks: 100 Duration: 3 Hours

COMPUTATIONAL METHODS IN CHEMICAL ENGINEERING

(2019-Scheme)

PART A

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

1 Explain about the different errors encountered during numerical methods.

2 Obtain an iterative formula to find $\frac{1}{\sqrt{N}}$, and evaluate $\frac{1}{\sqrt{14}}$ using Newton Raphson method..

3 Write the procedure of Rayleigh Power method to determine numerically largest Eigen value.

4 Write a note on instabilities of simultaneous equations.

5 Explain briefly about piecewise interpolation.

6 Give the various forms of polynomials that are used in deriving interpolation functions.

7 Differentiate between simple difference and divided difference.

8 Discuss the difference between Trapezoidal integration and Simpsons integration

9 Distinguish corrector formula from predictor formula.

10 Compare the Taylor series and Runge-Kutta methods.

PART B

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

Module –I

11 Air at 25°C and 1 atm flows through a 4 mm diameter tube with an average velocity of 50 m/s. The roughness is ε = 0.0015 mm. Make use of Newton – 14

Raphson method to determine the friction factor using the Colebrook equation.

$$\frac{1}{f} = -2.0\ log\left(\frac{\varepsilon/D}{3.7} + \frac{2.51}{R_e\sqrt{f}}\right)$$

Determine the pressure drop in a 1 m section of the tube using the relation

$$\Delta P = \frac{fL\bar{V}\rho}{2D}$$

Density of the air at 25°C and 1 atm is 1.23 kg/m^3 and the viscosity is 1.79 X 10^{-5} kg/ms.

12 a Make use of Graeffe's root squaring method to find the roots of $f(x) = x^3 + x^2 - 4x - 4$ (squaring twice) 6

12 b Make use of Muller's method to find the roots of $f(x) = x^3 + x^2 - 4x - 4$ 8

Module – II

13 a Solve the equations given below by Relaxation methods 9

$$10x - 2y - 3z = 205; -2x + 10y - 2z = 154; -2x - y + 10z = 120$$

13 b Solve the following equations by Gauss-Seidal Method 5

$$10x + y + z = 12$$
$$2x + 10y + z = 13$$
$$2x + 2y + 10z = 14$$

14 a Determine the largest eigen value and corresponding eigen vector of the matrix A using Power method: 7

$$\begin{matrix} 2 & -1 & 0 \\ -1 & 2 & -1 \\ 0 & -1 & 2 \end{matrix}$$

14 b Solve the system of non-linear equations using Newton Raphson method: 7

$x^2 + y = 11, y^2 + x = 7$

Module – III

15 a The following data gives the melting point of an alloy of lead and zinc, where t is the temperature in ^{0}C and P is the percentage of lead in the alloy: 7

p	40	50	60	70	80	90
t	184	204	226	250	276	304

Using Newton's interpolation formula, find the melting point of the alloy containing 84 percent of lead.

15 b Derive Newton's divided difference interpolation formula 7

16 a The velocity v (km/min) of a moped which starts from rest is given at fixed 7

intervals of time t (min) as follows:

t	2	4	6	8	10	12	14	16	18	20
v	10	18	25	29	32	20	11	5	2	0

Estimate approximately, the distance covered in 20 minutes.

16 b If $y_1=4$, $y_3=12$, $y_4=19$ and $y_x=7$, determine x using Lagrange inverse interpolation. 7

Module – IV

17 a Derive Newton's forward difference and backward difference formula 8

17 b The following data gives the velocity of a particle for 20 seconds at an interval of 5 seconds. Find the initial acceleration using the entire data: 6

Time, t (sec)	0	5	10	15	20
Velocity, v (m/s)	0	3	14	69	228

18 In an attempt to understand the mechanism of the depolarization process in a fuel cell, an electro-kinetic model for mixed oxygen-methanol current on platinum was developed in the laboratory at FAMU. A very simplified model of the reaction developed suggests a functional relation in an integral form. To find the time required for 50% of the oxygen to be consumed, the time, *T(s)* is given by 14

$$T - - \int_{1.22*10^{-6}}^{0.61*10^{-6}} \left| \frac{6.73x + 4.3025 * 10^{-7}}{2.316 * 10^{-11}x} \right| dx$$

Use Simpson's 1/3 rule with n = 8 to find the time required for 50 % of the oxygen to be consumed.

Module – V

19 Solve the equation below subject to the initial condition u(x, y, 0) = sin 2πx sin 2πy, 0 ≤ x, y ≤ 1, and the conditions u(x, y, t) = 0, t > 0 on the boundaries. 14

$$\frac{\partial u}{\partial t} = \frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2}$$

Obtain the solution up to one time level with h = 1/3 and α = 1/8

20 a The concentration of salt x in a homemade soap maker is given as a function of time by 10

$$\frac{dx}{dt} = 37.5 - 3.5x$$

At the initial time, t = 0, the salt concentration in the tank is 50 g/L Using Runge-Kutta 4th order method and a step size of, h = 0.75 min, determine

the salt concentration after 3 minutes.

20 b Using modified Eulers method, obtain the solution of the differential equation 4

$\frac{dy}{dx} = x + \sqrt{y}$ with initial condition y(0)=1, for range $0 \le x \le 0.4$ in steps of 0.2.

Syllabus

Module 1:

Errors in numerical calculations, Sources of errors, significant digits and numerical instability - numerical solution of polynomial and transcendental equations - bisection method - method of false position - Newton-Raphson method - fixed-point iteration - rate of convergence of these methods - iteration based on second degree equation - the Muller's method - Chebyshev method - Graeffe's root squaring method for polynomial equations - Bairstow's method for quadratic factors in the case of polynomial equations

Module 2

Solutions of system of linear algebraic equations. Direct methods - gauss and gauss - Jordan methods - Crout's reduction method - error analysis - iterative methods - Jacobi's iteration - Gauss-seidel iteration - the relaxation method - convergence analysis - solution of system of nonlinear equations by Newton-Raphson method - power method for the determination of Eigen values - convergence of power method

Module 3

Polynomial interpolation. Lagrange's interpolation polynomial - divided differences Newton's divided difference interpolation polynomial - error of interpolation - finite difference operators - Gregory – Newton forward and backward interpolations - Stirling's interpolation formula.

Module 4

Numerical differentiation - differential formulas in the case of equally spaced points - numerical integration - trapezoidal and Simpson's rules - Gaussian integration - errors of integration formulas.

Module 5

Numerical solution of ordinary differential equations. The Taylor series method - Euler and modified Euler methods - Runge–Kutta methods (2nd order and 4th order only) - multistep methods - Milne's predictor - corrector formulas - Adam-Bashforth & Adam-Moulton formulas

Solution of boundary value problems in ordinary differential equations - finite difference methods for solving two dimensional Laplace's equation for a rectangular region - finite difference method of solving heat equation and wave equation with given initial and boundary conditions

Reference Books

1. Ajay K. Ray, Mathematical Methods in Chemical & Environmental Engineering, Thomson-Learning
2. Steven C. Chapra and Raymond P. Canal, Numerical Methods for Engineers, McGraw-Hill
3. S. K. Gupta, Numerical Methods for Engineers, New Age Intl. Publishers (earlier: Wiley Eastern, New Delhi), 1995, 407 pages. Second Edition, 2010 Froberg C.E., Introduction to Numerical Analysis, Addison Wesley
4. Gerald C.F., Applied Numerical Analysis, Addison Wesley
5. Hildebrand F.B., Introduction to Numerical Analysis, T.M.H.
6. James M.L., Smith C.M. & Wolford J.C., Applied Numerical Methods for Digital Computation, Harper & Row
7. Mathew J.H., Numerical Methods for Mathematics, Science and Engineering, P.H.I

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Module 1 (10 hours)**	
1.1	Errors in numerical calculations, Sources of errors, significant digits and numerical instability	2
1.2	numerical solution of polynomial and transcendental equations - bisection method - method of false position - Newton-Raphson method - fixed-point iteration - rate of convergence of these methods	4
1.3	Iteration based on second degree equation - the Muller's method - Chebyshev method - Graeffe's root squaring method for polynomial equations	3
1.4	Bairstow's method for quadratic factors in the case of polynomial equations	1
2	**Module 2 (9 hours)**	
2.1	Solutions of system of linear algebraic equations. Direct methods - gauss and gauss - Jordan methods - Crout's reduction method - error analysis -	3
2.2	Solutions of system of linear algebraic equations- iterative methods - Jacobi's iteration - Gauss-seidel iteration - the relaxation method - convergence analysis.	3
2.3	Solution of system of nonlinear equations by Newton-Raphson method.	2
2.4	Power method for the determination of Eigen values - convergence of power method.	1
3	**Module 3 (7 hours)**	
3.1	Polynomial interpolation. Lagrange's interpolation polynomial	2
3.2	divided differences Newton's divided difference interpolation polynomial - error of interpolation -	3
3.3	Finite difference operators - Gregory – Newton forward and backward interpolations - Stirling's interpolation formula.	2

4	**Module 4 (6 hours)**	
4.1	Numerical differentiation - differential formulas in the case of equally spaced points	3
4.2	Numerical integration - trapezoidal and Simpson's rules - Gaussian integration - errors of integration formulas.	3
4.3		
5	**Module 5 (13 hours)**	
5.1	Numerical solution of ordinary differential equations. The Taylor series method -	1
5.2	Euler and modified Euler methods - Runge–Kutta methods (2nd order and 4th order only) -	2
5.3	multistep methods - Milne's predictor - corrector formulas - Adam-Bashforth & Adam-Moulton formulas	2
5.4	Solution of boundary value problems in ordinary differential equations -	2
5.5	Solution to PDE's finite difference methods for solving two dimensional Laplace's equation for a rectangular region	3
5.6	finite difference method of solving heat equation and wave equation with given initial and boundary conditions	3

MATHEMATICS – 4 th semester

(All branches except Electrical, Electronics, Computer science, Information Technology and Applied Electronics)

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
MAT 202	PROBABILITY,STATISTICS AND NUMERICAL METHODS	BASIC SCIENCE COURSE	3	1	0	4

Preamble: This course introduces students to the modern theory of probability and statistics, covering important models of random variables and techniques of parameter estimation and hypothesis testing. A brief course in numerical methods familiarises students with some basic numerical techniques for finding roots of equations, evaluationg definite integrals solving systems of linear equations, and solving ordinary differential equations which are especially useful when analytical solutions are hard to find.

Prerequisite: A basic course in one-variable and multi-variable calculus.

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

CO 1	Understand the concept, properties and important models of discrete random variables and,using them, analyse suitable random phenomena.
CO 2	Understand the concept, properties and important models of continuous random variables and,using them, analyse suitable random phenomena.
CO 3	Perform statistical inferences concerning characteristics of a population based on attributes of samples drawn from the population
CO 4	Compute roots of equations, evaluate definite integrals and perform interpolation on given numerical data using standard numerical techniques
CO 5	Apply standard numerical techniques for solving systems of equations, fitting curves on given numerical data and solving ordinary differential equations.

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	2	2					2		1
CO 2	3	2	2	2	2					2		1
CO 3	3	2	2	2	2					2		1
CO 4	3	2	2	2	2					2		1
CO 5	3	2	2	2	2					2		1

Assessment Pattern

Bloom's Category	Continuous Assessment Tests(%)		End Semester Examination(%)
	1	2	
Remember	10	10	10
Understand	30	30	30
Apply	30	30	30
Analyse	20	20	20
Evaluate	10	10	10
Create			

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. Let X denote the number that shows up when an unfair die is tossed. Faces 1 to 5 of the die are equally likely, while face 6 is twice as likely as any other. Find the probability distribution, mean and variance of X.

2. An equipment consists of 5 componets each of which may fail independently with probability 0.15. If the equipment is able to function properly when at least 3 of the componets are operational, what is the probability that it functions properly?

3. X is a binomial random variable $B(n,p)$with $n = 100$and $p = 0.1$. How would you approximate it by a Poisson random variable?

4. Three balls are drawn at random without replacement from a box containing 2 white, 3 red and 4 black balls. If X denotes the number of white balls drawn and Y denotes the number of red balls drawn, find the joint probability distribution of (X,Y)

Course Outcome 2 (CO2)

1. What can you say about $P(X = a)$for any real number $a$when $X$is a (i) discrete random variable? (ii) continuous random variable?

2. A string, 1 meter long, is cut into two pieces at a random point between its ends. What is the probability that the length of one piece is at least twise the length of the other?

3. A random variable has a normal distribution with standard deviation 10. If the probability that it will take on a value less than 82.5 is 0.82, what is the probability that it will take on a value more than 58.3?

4. X and Y are independent random variables with X following an exponential distribution with parameter μ and Y following and exponential distribution with parameter λ. Find $P(X + Y \leqslant 1)$

Course Outcome 3(CO3):

1. In a random sample of 500 people selected from the population of a city 60 were found to be left-handed. Find a 95% confidence interval for the proportion of left-handed people in the city population.

2. What are the types of errors involved in statistical hypothesis testing. Explain the level of risks associated with each type of error.

3. A soft drink maker claims that a majority of adults prefer its leading beverage over that of its main competitor's. To test this claim 500 randomly selected people were given the two beverages in random order to taste. Among them, 270 preferred the soft drink maker's brand, 211 preferred the competitor's brand, and 19 could not make up their minds. Determine whether there is sufficient evidence, at the 5% level of significance, to support the soft drink maker's claim against the default that the population is evenly split in its preference.

4. A nutritionist is interested in whether two proposed diets, *diet A* and *diet B* work equally well in providing weight-loss for customers. In order to assess a difference between the two diets, she puts 50 customers on diet A and 60 other customers on diet B for two weeks. Those on the former had weight losses with an average of 11 pounds and a standard deviation of 3 pounds, while those on the latter lost an average of 8 pounds with a standard deviation of 2 pounds. Do the diets differ in terms of their weight loss?

Course Outcome 4(CO4):

1. Use Newton-Raphson method to find a real root of the equation $f(x) = e^{2x} - x -$ 6correct to 4 decimal places.

2. Compare Newton's divided difference method and Langrange's method of interpolation.

3. Use Newton's forward interpolation formula to compute the approximate values of the function f at $x = 0.25$ from the following table of values of x and $f(x)$

x	0	0.5	1	1.5	2
f(x)	1.0000	1.0513	1.1052	1.1618	1.2214

4. Find a polynomial of degree 3 or less the graph of which passes thorugh the points (-1,3), (0,-4), (1,5) and (2,-6)

Course Outcome 5 (CO5):

1. Apply Gauss-Seidel method to solve the following system of equations

$$4x_1 - x_2 - x_3 = 3$$
$$-2x_1 + 6x_2 + x_3 = 9$$
$$-x_1 + x_2 + 7x_3 = -6$$

2. Using the method of least squares fit a straight line of the form $y = ax + b$ to the following set of ordered pairs (x, y) :
(2,4), (3,5), (5,7), (7,10), (9,15)

3. Write the normal equations for fitting a curve of the form $y = a_0 + a_1x^2$ to a given set of pairs of data points.

4. Use Runge-Kutta method of fourth order to compute $y(0.25)$ and $y(0.5)$, given the initial value problem

$$y' = x + xy + y, y(0) = 1$$

Syllabus

Module 1 (Discrete probability distributions) **9 hours**

(Text-1: *Relevant topics* from sections-3.1-3.4, 3.6, 5.1)

Discrete random variables and their probability distributions, Expectation, mean and variance, Binomial distribution, Poisson distribution, Poisson approximation to the binomial distribution, Discrete bivariate distributions, marginal distributions, Independent random variables, Expectation -multiple random variables.

Module 2 (Continuous probability distributions) **9 hours**

(Text-1:*Relevant topics* from sections-4.1-4.4, 3.6, 5.1)

Continuous random variables and their probability distributions, Expectation, mean and variance, Uniform, exponential and normal distributions, Continuous bivariate distributions, marginal distributions, Independent random variables, Expectation-multiple random variables, i.i.d random variables and Central limit theorem (**without proof**).

Module 3 (Statistical inference) **9 hours**

(Text-1:*Relevant topics* from sections-5.4,, 3.6, 5.1,7.2, 8.1, 8.3, 9.1-9.2,9.4)

Population and samples, Sampling distribution of the mean and proportion (for large samples only), Confidence interval for single mean and single proportions(for large samples only). Test of hypotheses: Large sample test for single mean and single proportion, equality of means and equality of proportions of two populations, small sample t-tests for single mean of normal population, equality of means (**only pooled t-test, for independent samples from two normal populations with equal variance**)

Module 4 (Numerical methods -I) **9 hours**

(Text 2- *Relevant topics* from sections 19.1, 19.2, 19.3, 19.5)

Errors in numerical computation-round-off, truncation and relative error, Solution of equations – Newton-Raphson method and Regula-Falsi method. Interpolation-finite differences, Newton's forward and backward difference method, Newton's divided difference method and Lagrange's method. Numerical integration-Trapezoidal rule and Simpson's 1/3rd rule (**Proof or derivation of the formulae not required for any of the methods in this module**)

Module 5 (Numerical methods -II) **9 hours**

(Text 2- *Relevant topics* from sections 20.3, 20.5, 21.1)

Solution of linear systems-Gauss-Siedal and Jacobi iteration methods. Curve fitting-method of least squares, fitting staright lines and parabolas. Solution of ordinary differential equations-Euler and Classical Runge-Kutta method of second and fourth order, Adams-Moulton predictor-correction method (**Proof or derivation of the formulae not required for any of the methods in this module**)

Text Books

1. (Text-1) Jay L. Devore, *Probability and Statistics for Engineering and the Sciences*, 8th edition, Cengage, 2012

2. (Text-2) Erwin Kreyszig, *Advanced Engineering Mathematics,* 10 th Edition, John Wiley & Sons, 2016.

Reference Books

1. Hossein Pishro-Nik, *Introduction to Probability, Statistics and Random Processes*, Kappa Research, 2014 (Also available online at www.probabilitycourse.com)
2. Sheldon M. Ross, *Introduction to probability and statistics for engineers and*

scientists, 4th edition, Elsevier, 2009.

3. T. Veera Rajan, *Probability, Statistics and Random processes,* Tata McGraw-Hill, 2008

4. B.S. Grewal, *Higher Engineering Mathematics*, Khanna Publishers, 36 Edition, 2010.

Assignments

Assignments should include specific problems highlighting the applications of the methods introduced in this course in physical sciences and engineering.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Discrete Probability distributions**	**9 hours**
1.1	Discrete random variables and probability distributions, expected value, mean and variance (discrete)	3
1.2	Binomial distribution-mean, variance, Poisson distribution-mean, variance, Poisson approximation to binomial	3
1.3	Discrete bivariate distributions, marginal distributions, Independence of random variables (discrete), Expected values	3
2	**Continuous Probability distributions**	**9 hours**
2.1	Continuous random variables and probability distributions, expected value, mean and variance (continuous)	2
2.2	Uniform, exponential and normal distributions, mean and variance of these distributions	4
2.3	Continuous bivariate distributions, marginal distributions, Independent random variables, Expected values, Central limit theorem.	3
3	**Statistical inference**	**9 hours**
3.1	Population and samples, Sampling distribution of single mean and single proportion(large samples)	1
3.2	Confidence interval for single mean and single proportions (large samples)	2
3.3	Hypothesis testing basics, large sample test for single proportion, single proportion	2
3.4	Large sample test for equality of means and equality of proportions of two populations	2

3.5	t-distribution and small sample t-test for single mean and pooled t-test for equality of means	2
4	**Numerical methods-I**	**9 hours**
4.1	Roots of equations- Newton-Raphson, regulafalsi methods	2
4.2	Interpolation-finite differences, Newton's forward and backward formula,	3
4.3	Newton's divided difference method, Lagrange's method	2
4.3	Numerical integration-trapezoidal rule and Simpson's 1/3-rd rule	2
5	**Numerical methods-II**	**9 hours**
5.1	Solution of linear systems-Gauss-Siedal method, Jacobi iteration method	2
5.2	Curve-fitting-fitting straight lines and parabolas to pairs of data points using method of least squares	2
5.3	Solution of ODE-Euler and Classical Runge-Kutta methods of second and fourth order	4
5.4	Adams-Moulton predictor-corrector methods	1

Model Question Paper

(2019 Scheme)

Reg No: ..... **Total Pages: 4**

Name: .....

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FOURTH SEMESTER B.TECH DEGREE EXAMINATION

(Month & year)

Course Code: MAT

Course Name: PROBABILITY, STATISTICS AND NUMERICAL METHODS

(Common to all branches except (i) Electrical and Electronics, (ii) Electronics and Communication, (iii) Applied Electronics and Instrumentation (iv) Computer Science and Engineering (v) Information Technology)

Max Marks :100 Duration : 3 Hours

PART A

(Answer *all* questions. Each question carries 3 marks)

1. Suppose X is binomial random variable with parameters $n = 100$ and $p = 0.02$. Find $P(X < 3)$ using Poisson approximation to X. (3)

2. The diameter of circular metallic discs produced by a machine is a random variable with mean 6cm and variance 2cm. Find the mean area of the discs. (3)

3. Find the mean and variance of the continuous random variable X with probability density function (3)
$$f(x) = \begin{cases} 2x - 4, & 2 \le x \le 3 \\ 0 & \text{otherwise} \end{cases}$$

4. The random variable X is exponentially distributed with mean 3. Find $P(X > t + 3 | X > t)$ where t is any positive real number. (3)

5. The 95% confidence interval for the mean mass (in grams) of tablets produced by a machine is [0.56 0.57], as calculated from a random sample of 50 tablets. What do you understand from this statement? (3)

6. The mean volume of liquid in bottles of lemonade should be at least 2 litres. A sample of bottles is taken in order to test whether the mean volume has fallen below 2 litres. Give a null and alternate hypothesis for this test and specify whether the test would be one-tailed or two-tailed. (3)

7. Find all the first and second order forward and backward differences of y for the following set of (x, y) values: (0.5, 1.13), (0.6, 1.19), (0.7, 1.26), (0.8, 1.34) (3)

8. The following table gives the values of a function $f(x)$ for certain values of x. (3)

x	0	0.25	0.50	0.75	1
$f(x)$	1	0.9412	0.8	0.64	0.5

Evaluate $\int_0^1 f(x)dx$ using trapezoidal rule.

9. Explain the principle of least squares for determining a line of best fit to a given data (3)

10. Given the initial value problem $y' = y + x$, $y(0) = 0$, find $y(0.1)$ and $y(0.2)$ using Euler method. (3)

PART B
(Answer one question from each module)

MODULE 1

11. (a) The probability mass function of a discrete random variable is $p(x) = kx, x = 1, 2, 3$ where k is a positive constant. Find (i)the value of k (ii) $P(X \leq 2)$ (iii) $E[X]$ and (iv) var$(1 - X)$. (7)

    (b) Find the mean and variance of a binomial random variable (7)

OR

12. (a) Accidents occur at an intersection at a Poisson rate of 2 per day. what is the probability that there would be no accidents on a given day? What is the probability that in January there are at least 3 days (not necessarily consecutive) without any accidents? (7)

    (b) Two fair dice are rolled. Let X denote the number on the first die and $Y = 0$ or 1, according as the first die shows an even number or odd number. Find (i) the joint probability distribution of X and Y, (ii) the marginal distributions. (iii) Are X and Y independent ? (7)

MODULE 2

13. (a) The IQ of an individual randomly selected from a population is a normal distribution with mean 100 and standard deviation 15. Find the probability that an individual has IQ (i) above 140 (ii) between 120 and 130. (7)

    (b) A continuous random variable X is uniformly distributed with mean 1 and variance 4/3. Find $P(X < 0)$ (7)

OR

14. (a) The joint density function of random variables X and Y is given by (7)

$$f(x, y) = \begin{cases} e^{-(x+y)}, & x > 0, \quad y > 0 \\ 0 & \text{otherwise.} \end{cases}$$

    Find $P(X + Y \leq 1)$. Are X and Y independent? Justify.

    (b) The lifetime of a certain type of electric bulb may be considered as an exponential random variable with mean 50 hours. Using central limit theorem, find the approximate probability that 100 of these electric bulbs will provide a total of more than 6000 hours of burning time. (7)

MODULE 3

15. (a) The mean blood pressure of 100 randomly selected persons from a target population is 127.3 units. Find a 95% confidence interval for the mean blood pressure of the population. (7)

    (b) The CEO of a large electric utility claims that 80 percent of his 1,000,000 customers are very satisfied with the service they receive. To test this claim, the local newspaper surveyed 100 customers, using simple random sampling. Among the sampled customers, 73 percent say they are very satisfied. Based on these findings, do you think that the CEO is making a false claim of high satisfaction levels among his customers? Use a 0.05 level of significance. (7)

OR

16. (a) A magazine reported the results of a telephone poll of 800 adult citizens of a country. The question posed was: "Should the tax on cigarettes be raised to pay for health care reform?" The results of the survey were: Out of the 800 persons surveyed, 605 were non-smokers out of which 351 answered "yes" and the rest "no". Out of the remaining 195, who were smokers, 41 answered "yes" and the remaining "no". Is there sufficient evidence, at the 0.05 significance level, to conclude that the two populations smokers and non-smokers differ significantly with respect to their opinions? (7)

(b) Two types of cars are compared for acceleration rate. 40 test runs are recorded for each car and the results for the mean elapsed time recorded below: (7)

	Sample mean	Sample standard deviation
Car A	7.4	1.5
Car B	7.1	1.8

determine if there is a difference in the mean elapsed times of the two car models at 95% confidence level.

MODULE 4

17. (a) Use Newton-Raphson method to find a non-zero solution of $x = 2\sin x$. Start with $x_0 = 1$ (7)

(b) Using Lagrange's interpolating polynomial estimate $f(1.5)$ for the following data (7)

x	0	1	2	3
$y = f(x)$	0	0.9826	0.6299	0.5532

OR

18. (a) Consider the data given in the following table (7)

x	0	0.5	1	1.5	2
$f(x)$	1.0000	1.0513	1.1052	1.1618	1.2214

Estimate the value of $f(1.80)$ using newton's backward interpolation formula.

(b) Evaluate $\int_0^1 e^{-x^2/2}dx$ using Simpson's one-third rule, dividing the interval [0, 1] into 8 subintervals (7)

MODULE 5

19. (a) Using Gauss-Seidel method, solve the following system of equations (7)

$$20x + y - 2z = 17$$
$$3x + 20y - z = -18$$
$$2x - 3y + 20z = 25$$

(b) The table below gives the estimated population of a country (in millions) for during 1980-1995 (7)

year	1980	1985	1990	1995
population	227	237	249	262

Plot a graph of this data and fit an appropriate curve to the data using the method of least squares. Hence predict the population for the year 2010.

OR

20. (a) Use Runge-Kutta method of fourth order to find $y(0.2)$ given the initial value problem (7)

$$\frac{dy}{dx} = \frac{xy}{1+x^2}, \quad y(0) = 1$$

Take step-size, $h = 0.1$.

(b) Solve the initial value problem (7)

$$\frac{dy}{dx} = x + y, \quad y(0) = 0,$$

in the interval $0 \leq x \leq 1$, taking step-size $h = 0.2$. Calculate $y(0.2), y(0.4)$ and $y(0.6)$ using Runge-Kutta second order method, and $y(0.8)$ and $y(1.0)$ using Adam-Moulton predictor-corrector method.

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SEMESTER V

CHT 301	MASS TRANSFER OPERATIONS -I	CATEGORY	L	T	P	CREDIT
		PCC	3	1	0	4

Preamble: The analysis of the phenomena of mass transfer is important in engineering design applications. The objective of this course is to study the principles of mass transfer and their application to separation and purification processes. The course integrates fluid dynamics and thermodynamics and proceeds to develop rate expressions for mass transfer in gases, liquids and solids. This course also explains how to solve engineering problems involving different mass transfer operations like absorption, drying, adsorption, humidification and crystallization processes.

Prerequisite: Basic knowledge in Chemical Process Principles and Fluid and Particle Mechanics

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

CO 1	Analyse fundamentals of mass transfer operations and estimate diffusion coefficients
CO 2	Summarize interface mass transfer and concepts of mass transfer coefficients
CO 3	Differentiate among different types of equipments for mass transfer operations
CO 4	Analyse and design tray and packed columns of gas liquid contacting equipments
CO 5	Analyse and design humidification and adsorption systems
CO 6	Analyse and design drying and crystallization 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										
CO 2	3	3										
CO 3	3											
CO 4	3	3	3									
CO 5	3	3										
CO 6	3	3										

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	10
Understand	10	10	10
Apply	20	20	60
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.

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Course Level Assessment Questions

Course Outcome 1 (CO1): Analyse fundamentals of mass transfer operations and estimate diffusion coefficients

1. Show that $D_{AB} = D_{BA}$ for a binary mixture

2. State and explain Film theory of mass transfer

3. Derive the equation for steady state diffusion in multi component mixtures

Course Outcome 2 (CO2): Summarize interface mass transfer and concepts of mass transfer coefficients

1. Define mass transfer coefficient

2. Derive the relationship between overall and individual mass transfer coefficient

3. Find out the relationship between F- type and k- type mass transfer coefficient

Course Outcome 3(CO3): Differentiate among different types of equipments for mass transfer operations

1. Compare tray tower and packed tower

2. Describe Flooding in packed bed absorption column

3. With a neat sketch describe venturi scrubbers

Course Outcome 4 (CO4): Analyse and design tray and packed columns of gas liquid contacting equipments

1. With neat sketch, describe the constructional features and design constraints of a packed tower.

2. Derive the equation for operating curve for a counter current absorption tower and draw graphs for absorption and stripping

3. 1000kg/hr acetone air mixture containing 2mole% acetone is admitted into a continuous counter current absorber operating at atmospheric pressure and at a constant temperature of 27^0C. It is scrubbed with pure water at a rate of 25% more than the minimum required such that 90% of acetone from the gas phase is absorbed. The equilibrium relationship is given by the equation y = 2.53x where x and y are mole fraction. Given: $H_{tG} = 0.353$m, $H_{tL} = 0.323$m. Gas mixture can be assumed dilute. Calculate the height of the tower.

Course Outcome 5 (CO5): Analyse and design humidification and adsorption systems

1. Compare different types of cooling towers and derive the height of the cooling tower using transfer units

2. Explain adsorption isotherm and application of Freundlich Equation to a single stage adsorption process.

3. Equilibrium adsorption for de-colourisation is represented by $Y= 0.003X^2$ where X is kg of colour / kg of adsorbent and Y is kg of colour / kg of colour carrier. Calculate the % removal of colour if 50 kg of colour carrying material containing 1 part of colour per 3 parts of carrier is treated with (i) 15 kg adsorbent in a single stage operation (ii) Using 7.5 kg adsorbent in each stage of two stages cross current unit.

Course Outcome 6 (CO6): Analyse and design drying and crystallization systems

1. Obtain an expression to determine the drying time needed to dry a substance possessing constant rate drying.

2. A crystallizer is charged with 7500kg of aqueous solution at 104^0C containing 30% by weight of Na_2SO_4. The solution is then cooled to 20^0C. During this operation 5% of the original water is lost by evaporation. Glauber salt crystallizes and the solubility at 20^0C is 19.4gm of Na_2SO_4 / 100gm of water. Find the weight of (i) Water lost by evaporation (ii) Crystals formed (iii) Mother liquor leaving.

3. A wet solid is dried from 40 % moisture to 8% moisture in 4 hrs. How long will it take to dry the material to 5% moisture under the same drying conditions. Equilibrium moisture content 4% and critical moisture content of the material was 15% (moisture content in wet basis).

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Model Question Paper

QP CODE: **PAGES: 3**

Reg No: _____ **Name: _____**

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIFTH SEMESTER B. TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: CHT301

Max. Marks: 100 Duration: 3 Hours

MASS TRANSFER OPERATIONS - I

PART – A

Answer All the Questions (10 x 3 = 30)

1. State and explain Fick's law of molecular diffusion.
2. Derive the equation for mass transfer coefficient.
3. Explain characteristics of packing materials using in packed columns.
4. Explain flooding and weeping a tray column
5. Explain HTU and NTU
6. Differentiate between physical adsorption and chemisorption
7. What are the different cooling towers are available in industries
8. Explain the principle of wet bulb thermometry
9. Explain application of drying
10. Explain different methods of achieving super saturation.

PART – B

Answer one full question from each module (5 x 14 = 70)

Module 1

11 a) State and explain Film theory of mass transfer.

b) Consider two cases for a binary mixture of ideal gases A and B under steady state conditions. In case 1 the diffusion of A occurs through non-diffusing B. in case 2 equimolal counter diffusion of A and B occurs. In both the cases the total pressure is 100 kPa and the partial pressure of A at two points separated at a distance of 10mm are 10 kPa and 5 kPa. Assume that Fick's law of molecular diffusion is applicable. What is the ratio of molar flux of A in case 1 to that in case 2? **(4+10 = 14 marks)**

OR

12 a) Derive the Reynolds analogy starting from fundamental transport equation for momentum, heat and mass. corresponding numbers in heat transfer

b) Diffusivity of toluene is measured by Stefan's method. A vertical glass tube of 3 mm diameter is filled with toluene to a depth of 19mm from top open end. After 275 hours at 37^0C and 1atm. total pressure the level has fallen to 79 mm. from top. Density of toluene is 850 kg/m^3 and Vapour Pressure 37^0C is 57.3 mm Hg Calculate the

diffusivity of Toluene in air. **(7+7= 14 marks)**

Module 2

13 a) Explain the principle and working of a venturi scrubber and mention its industrial applications

b) With neat sketch, describe the constructional features and design constraints of a packed tower. **(6+8=14 marks)**

OR

14 a) With neat sketch, describe the constructional features of a tray tower.

b) Explain with neat sketches the different types of packings and packing materials used. **(7+7=14 marks)**

Module 3

15 a) Derive the material balance equation for a gas liquid absorber operating under counter. current flow condition. Using this expression, explain how you will determine the minimum gas liquid ratio

b) Wash oil containing 0.007 kg hexane/kg oil is used in a counter current packed column absorber to scrub a feed gas stream containing 0.09 kg hexane/kg hexane free gas mixture. The outlet gas stream contains 0.001 kg hexane/kg hexane free gas mixture. Determine the height of packed section required to treat 1000 kg/(hr)(m2 of empty tower cross section) of hexane free gas mixture. The equilibrium relation may be taken as Y=1.5 X where Y and X are solute/non-solute mole ratio in gas phase and liquid phase respectively. The overall coefficient Kya may be taken as 350 kg/(hr) (m3) (unit gradient of y). The feed rate of hexane free wash oil is 5000 kg/(hr)(m2). **(6+8=14 marks)**

OR

16 a) Define Murphree stage efficiency

b) Derive Kremser equation for the determination of number of transfer units and state the assumptions used **(6+8=14 marks)**

Module 4

17 a) Explain adsorption wave and break through curve

b) Discuss the nature of adsorbents

c) Explain the principle of wet bulb thermometry and obtain an expression for wet bulb depression. **(4+4+6=14 marks)**

OR

18 a) Discuss briefly on adiabatic saturation curve

b) One litre flask is containing air and acetone at 1atm and 303K with a relative humidity of 35% after 2gm of fresh activated carbon is introduced and flask is sealed Compute the final vapour composition and final pressure neglecting adsorption of air. Vapour pressure of acetone at 30^0C is 283mm Hg.

Equilibrium data:

gm adsorbed/gm carbon	0	0.1	0.2	0.3	0.35
Partial pressure of acetone, mm Hg	0	2	12	42	92

(4+10=14 marks)

Module 5

19 a) Define: bound moisture, unbound moisture and free moisture

b) A wet solid is dried from 35 % moisture to 10% moisture in 5 hrs. How long will it take to dry the material to 6% moisture under the same drying conditions. Equilibrium moisture content 4% and critical moisture content of the material was 14% (moisture content in wet basis) **(6+8=14 marks)**

OR

20 a) Explain Mier's supersaturation theory

b) 1000kg of a 25% aqueous solution of Na_2CO_3 is slowly cooled to 20^0C.During cooling 10% water originally present evaporates. The crystal is $Na_2CO_3.10H_2O$. If the solubility of anhydrous Na_2CO_3 at 20^0C is 21.5kg/100kg of water, what weight of salt crystallizes out? **(5+9=14 marks)**

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Syllabus

Module 1 (10 Hr)

Molecular diffusion - mass fluxes J_A and N_A - Fick's law - diffusivity and estimation - steady state diffusion of A through stagnant B and equimolar counter diffusion in binary gases, liquids and multi component gas mixtures. Mass transfer coefficients, dimensionless groups - analogy between mass, heat and momentum transfer. Basic concepts and assumptions involved in theories of mass transfer: penetration and surface renewal theories - interphase mass transfer - equilibrium - diffusion between phases - two-film theory - local and overall k-type coefficients.

Module 2 (7 Hr)

Gas-Liquid contacting equipments for mass transfer operations - single stage and multistage contact , tray towers, tray types and general features of tray designs (qualitative treatment), continuous contact equipment, wetted wall columns, venturi scrubbers, packed columns, packing materials and characteristics, general constructional details of packed columns, Factors affecting column performance-flooding, priming, coning, weeping, loading etc, comparison between plate and packed columns.

Module 3 (10 Hr)

Gas absorption - Solubility of gases in liquid, choice of solvent, Material balance in counter current and co-current absorption and stripping, L/G ratio, Minimum gas liquid ratio, Multistage operation, number of plates by graphical construction, Kremser equation, tray efficiency, design of packed columns, transfer unit and general graphical method, dilute solutions and simplified design methods

Module 4 (10 Hr)

Humidification and dehumidification, Use of humidity chart to find properties of air, Lewis relation, water cooling with air, types of cooling towers, Design of cooling tower, spray chambers for air humidification, principles of gas dehumidification.

Adsorption, types of adsorption, properties of adsorbents, adsorption isotherm for single gases, vapours and dilute liquid solutions, Adsorption isotherms –Freundlich and Langmuir, Fixed bed adsorption, adsorption wave, rate of adsorption and breakthrough curve.

Module 5 (8 Hr)

Drying, equilibrium, bound and unbound moisture content, batch drying, rate of drying, mechanism of moisture movement, continuous drying, parallel and counter current, material and enthalpy balances, classification of industrial dryers for batch and continuous drying.

Crystallization, principles of crystallization, purity, yield, energy requirements, super saturation, nucleation-primary and secondary nucleation, growth of crystals-delta –L law, Ostwald ripening, crystallisation equipments- Classification of crystallizers, working and schematic diagram of forced circulation, draft tube baffled and Oslo crystallizers, MSMPR

Text Books:

1. Treybal R.E., Mass Transfer Operations, McGraw Hill.
2. Binay K Dutta, Principles of Mass Transfer & Separation Processes, PHI Learning Private Limited.

Reference Books:

1. K.V. Narayanan and B. Lakshmikutty. Mass Transfer-Theory and Applications, CBS Publishers.
2. N. Anantharaman and K.M.Meera Sheriffa Begum, Mass Transfer-Theory and Practice, PHI Learning Private Limited (2011) New Delhi.
3. Welty J.R., Wilson R.E. & Wicks C.E., Fundamentals of Momentum Heat and Mass Transfer, John Wiley
4. Foust A.S. et. al., Principles of Unit Operations, John Wiley
5. McCabe W.L., Smith J.C. & Harriot P., Unit Operations in Chemical Engineering, McGraw Hill.
6. Seader J.D.& Henley E.J Separation Process Principles, John Wiley & Sons
7. Coulson J.M. & Richardson J.F., Chemical Engineering, Vol. II, ELBS, Pergamon

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Course Contents and Lecture Schedule:

No.	Details	No. of Lectures
1	**Module 1**	**10**
1.1	Molecular diffusion - mass fluxes JA and NA - Fick's law -	1
1.2	Diffusivity and estimation -	1
1.3	Steady state diffusion of A through stagnant B and equimolar counter diffusion in binary gases,	1
1.4	Liquids and multi component gas mixtures. Mass transfer coefficients,	2
1.5	Dimensionless groups - analogy between mass, heat and momentum transfer.	1
1.6	Basic concepts and assumptions involved in theories of mass transfer: penetration and surface renewal theories	1
1.7	Interphase mass transfer - equilibrium - diffusion between phases	1
1.8	Two-film theory - local and overall k-type coefficients	2
2	**Module 2**	**7**
2.1	Gas-Liquid contacting equipments for mass transfer operations - single stage and multistage contact	1
2.2	Tray towers, tray types and general features of tray designs (qualitative treatment)	2
2.3	Wetted wall columns continuous contact equipment	1
2.4	Venturi scrubbers	1
2.5	Packed columns, packing materials and characteristics, general constructional details of packed columns	1
2.6	Factors affecting column performance-flooding, priming, coning, weeping, loading etc, comparison between plate and packed columns.	1
3	**Module 3**	**10**
3.1	Gas absorption - Solubility of gases in liquid, choice of solvent	1
3.2	Material balance in counter current and concurrent absorption and stripping	1
3.3	L/G ratio, minimum gas liquid ratio	1
3.4	Multistage operation number of plates by graphical construction, , tray efficiency,	1
3.5	Kremser equation	2
3.6	Design of packed columns, transfer unit and general graphical method	2
3.7	Dilute solutions and simplified design methods	2
4	**Module 4**	**10**
4.1	Humidification and dehumidification,	1
4.2	Use of humidity chart to find properties of air	1
4.3	Lewis relation, water cooling with air	1
4.4	Types of cooling towers, design of cooling tower	1
4.5	Spray chambers for air humidification, principles of gas	1

	dehumidification	
4.6	Adsorption, types of adsorption, properties of adsorbents,	1
4.7	Adsorption isotherm for single gases, vapours and dilute liquid solutions, Adsorption isotherms –Freundlich and Langmuir	2
4.8	Fixed bed adsorption, adsorption wave, rate of adsorption and breakthrough curve.	2
5	**Module 5**	**8**
5.1	Drying, equilibrium, bound and unbound moisture content, batch drying	1
5.2	Rate of drying, mechanism of moisture movement	1
5.3	Continuous drying, parallel and counter current, material and enthalpy balances, classification of industrial dryers for batch and continuous drying.	2
5.4	Crystallization, principles of crystallization, purity, yield, energy requirements	1
5.5	Super saturation, nucleation-primary and secondary nucleation, growth of crystals- delta–L law, Ostwald ripening	1
5.6	Crystallisation equipments- Classification of crystallizers, working and schematic diagram of forced circulation, draft tube baffled and Oslo crystallizers, MSMPR	2

CHT303	ENVIRONMENTAL ENGINEERING	CATEGORY	L	T	P	CREDIT
		PCC	3	1	0	4

Preamble: This course is indented to give fundamental understanding on the impact of chemical process industries on the environment and its remedial measures. Different pollution management strategies are discussed for addressing various modes of pollution.

Prerequisite: NIL

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

CO 1	Explain the environmental legislation and regulation aimed at protecting the environment from harmful actions.
CO 2	Explain the different types of treatment processes for drinking water, municipal water, boiler feed water and saline water.
CO 3	Interpret primary, secondary and tertiary treatment methods used for wastewater treatment.
CO 4	Compare aerobic and anaerobic wastewater treatment methods.
CO 5	Select suitable methods for treatment and disposal of sludge, industrial and hazardous waste.
CO 6	Identify the sources of air and noise pollution and select suitable control methods.

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					
CO 3	3						3					
CO 4	3		3				3					
CO 5	3		3				3					
CO 6	3						3					

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	20
Understand	20	20	20
Apply	20	20	40
Analyse			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. What are the important legislations and standards regarding water?
2. Explain the important legislations and standards regarding air.
3. How are the pollutants classified? Explain.

Course Outcome 2 (CO2):

1. Explain the precipitation processes used for water treatment?
2. Explain lime soda softening with relevant equations**.**
3. What are the methods used for boiler feed water treatment**?**

Course Outcome 3(CO3):

1. What are the factors to be considered in the design of a grit chamber?
2. Explain the working of an activated sludge process with a neat sketch**.**
3. What are the various disinfection methods for water**?**

Course Outcome 4 (CO4):

1. Explain suspended growth and attached growth processes. With a neat sketch describe the working of rotating biological contactors.
2. Explain the steps involved in the conversion of organic matter to biogas in an anaerobic process.
3. With a neat sketch explain the working of an up-flow anaerobic sludge blanket reactor**.**

Course Outcome 5 (CO5):

1. Differentiate between windrow and aerated static pile composting with neat sketches.
2. Describe the working of dissolved air flotation unit for sludge thickening.
3. Write a note on classification of solid waste. Explain the working of an incinerator.

Course Outcome 6 (CO6):

1. Explain the global effects of air pollution**.**
2. Describe the working of a bag filter for air pollution control.
3. What are the various sources of noise pollution? Explain various noise pollution control measures.

Model Question paper

QP CODE: PAGES:

Reg No:…… Name :…….

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIFTH SEMESTER B. TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: CHT 303

Max.Marks:100 Duration: 3 Hours

ENVIRONMENTAL ENGINEERING

(2019-Scheme)

PART A

(Answer all questions, each question carries 3 marks)

1. Write the important legislations and standards regarding water and air.
2. Differentiate temporary and permanent hardness? Explain the removal of both types of hardness.
3. Describe the factors to be considered in the design of a grit chamber.
4. Explain the working of trickling filters with a neat figure.
5. With neat sketch explain break point chlorination.
6. Explain the working of an anaerobic sludge digester.
7. Discuss about the classification of hazardous waste.
8. Explain air pollution meteorology.
9. Explain the working of an electrostatic precipitator.
10. Discuss about the sources and effects of noise pollution.

PART B

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

MODULE-I

11. a) Write in detail about the biological parameters regarding wastewater? (5)
    b) Explain the sampling methods used to determine BOD, COD, DO and TOC (9)
12. a) Explain any two precipitation processes used in water treatment? (10)
    b) Describe various physical characteristics of wastewater. (4)

MODULE-II

13. a) Discuss about the different types of settling? (5)
    b) Explain the primary treatment methods used for wastewater treatment (6)
    c) What are the different types of sedimentation tanks (9)
14. a) With neat figure explain the working of aerobic fluidised bed bioreactors. (7)
    b) Distinguish between the methods used to treat oily matter and finely divided suspended solids from wastewater? (7)

MODULE-III

15. a) Explain in detail the various methods for sludge thickening. (10)
    b) Describe the working of anaerobic sludge digester. (4)
16. a) With a neat figure, explain the treatment methods of pulp and paper mill waste. (7)
    b) Explain in detail about the treatment methods for hazardous waste? (7)

MODULE-IV

17. a) Describe air pollution sampling and analysis. (7)

    b) Explain the factors involved in the meteorological phenomena on air quality. (7)

18. Classify air pollutants. Explain in detail the sources of air pollution and their effects. (14)

MODULE-V

19. a) Describe the advantages and disadvantages of electrostatic precipitator. (7)

    b) Explain the characteristics of fabric and fibre used in the fabric filters. (7)

20. Describe the working of any four methods for gaseous emission control. (14)

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
KTU
Estd. 2014

Syllabus

Module 1: Introduction to Environmental Engineering-Water and Wastewater Treatment (9 Hours)

Introduction to environmental engineering–environmental legislation and regulation-water quality standards-Water treatment–precipitation processes-alum treatment and lime soda softening, municipal water conditioning-ion exchange processes, boiler feed water treatment–desalination. Sources and classification of wastewater- Types of water pollutants and their effects- Wastewater sampling, preservation and analysis- Physical, chemical and biological characteristics of wastewater-determination of solids and organic matter-dissolved oxygen (Oxygen Sag Curve) - biochemical oxygen demand-chemical oxygen demand - wastewater microbiology.

Module 2: Wastewater Treatment Methods (10 Hours)

Wastewater treatment methods - pretreatment - primary treatment - secondary treatment - tertiary treatment-advanced treatment methods. Screening, grit removal, oil removal and equalization-neutralization, coagulation, flocculation and sedimentation - clarifiers and clariflocculation. Aerobic and anaerobic biological processes - activated sludge process - trickling filters - oxidation ditch - aeration lagoon - rotating biological contactors - aerobic fluidized bed bioreactors. Anaerobic digestion process - anaerobic filter - anaerobic contact process - anaerobic fluidized bed bioreactors - up flow anaerobic sludge blanket (UASB) – Disinfections: Chlorination and Ozonation – Adsorption sand filters.

Module 3: Sludge treatment, Solid and Hazardous Waste Treatment (10 Hours)

Sludge treatment and disposal - sludge thickening - sludge conditioning - sludge dewatering - sludge digestion and composting.

Solid waste treatment-sources and classification-collection and disposal methods-open dumping-sanitary landfill-incineration-composting.

Treatment of industrial waste - pulp and paper mill - textile mill - distillery - dairy - petroleum refinery - fertilizer industry.

Hazardous waste -types of hazardous waste - health effects – treatment and disposal methods.

Module 4: Air Quality: Definition, Characteristics and Perspectives (8 Hours)

Air pollution: Units of measurement, sources, classification. Sampling and analysis of air pollutants, Effects of air pollution- global effects of air pollution - global warming and ozone depletion. Meteorological phenomena on air quality-lapse rates, Pressure, Wind, Moisture and dispersion. Air quality modelling: Pasquill's stability class, Gauss dispersion model, design of Stack height.

Module 5: Engineered Systems for Air and Noise Pollution Control (8 Hours)

Air pollution control methods and equipment. Control Devises for Particulate Contaminants: Gravitational settling, Centrifugal Collectors, Wet Collectors, Fabric filters and Electrostatic Precipitators (ESP) Control Devices for Gaseous Contaminants: Adsorption, Absorption,

Condensation, Combustion, Automobile Emission Control. Noise pollution - effects of noise on people-Noise control methods.

Text Books

1. Metcalf & Eddy, Wastewater Engineering: Treatment, Disposal and Reuse, McGraw-Hill
2. Peavy, H.S., Rowe, D.R. and Tchobanoglous, G., Environmental Engineering, McGraw-Hill
3. Sawyer and McCarty, Chemistry for Environmental Engineering, McGraw-Hill
4. Rao C.S., Environmental Pollution Control Engineering, New age International Pub.
5. Rao M.N. & Rao H., Air Pollution, Tata McGraw-Hill.
6. Tchobanoglous, Theisen and Eliassen, Solid wastes: Engineering Principles and Management Issues, McGraw-Hill

Reference Books

1. Austin G.T. (Ed.), Shreve's Chemical Process Industries, McGraw-Hill
2. Babbitt H.E., Sewage & Sewage Treatment, John Willey
3. Chemtech I, Chem. Eng. Curriculum Dev. Centre, IIT-Madras
4. Gopal Rao M. & Sittig M. (Eds.), Dryden's Outlines of Chemical Technology, Affiliated East West Press.
5. Mahajan S.P., Pollution Control in Process Industries, Tata McGraw-Hill
6. Perkins H.C., Air Pollution, McGraw-Hill
7. Sincero A.P. & Sincero G.A., Environmental Engineering-A Design Approach, Prentice Hall of India

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Introduction to Environmental Engineering-Water and Wastewater Treatment (9 Hours)**	
1.1	Environmental legislation and regulation-water quality standards (WHO, IS 10500:1991 Standard)-Water treatment methods	1 Hour
1.2	Sources of wastewater, Types of water pollutants and effects	1 Hour
1.3	Wastewater sampling, preservation and analysis	1 Hour
1.4	Physico-chemical characteristics of wastewater	2 Hours
1.5	DO (Oxygen Sag), BOD and COD of wastewater	2 Hours
1.6	Biological Characteristics of wastewater	2 Hours
2	**Wastewater Treatment Methods (10 Hours)**	
2.1	Primary Treatment	2 Hours
2.2	Secondary Treatment: Aerobic Process	2 Hours
2.3	Secondary Treatment: Anaerobic Process	3 Hours
2.4	Tertiary treatment: Sand filter, Adsorption, Ion-exchange, Disinfection	3 Hours
3	**Sludge treatment, Solid and Hazardous Waste Treatment (10 Hours)**	

3.1	Sludge from various stages, Treatment and Disposal methods	2 Hours
3.2	Solid waste treatment: sources, classification - collection and disposal methods	3 Hours
3.3	Industrial Waste treatment methods: pulp and paper mill - textile mill - distillery - dairy - petroleum refinery - fertilizer industry	3 Hours
3.4	Hazardous waste disposal: Types, health effect, treatment & disposal	2 Hours
4	**Air Quality: Definition, Characteristics and Perspectives (8 Hours)**	
4.1	Air pollution: Units of measurement, sources, classification	2 Hours
4.2	Sampling and analysis, Effects of air pollution	2 Hours
4.3	Meteorological phenomena on air quality-lapse rates, Pressure, Wind, Moisture and dispersion	1 Hour
4.4	Air quality modelling: Pasquill's stability class, Gauss dispersion model, design of Stack height (Numerical Problem)	3 Hours
5	**Engineered Systems for Air and Noise Pollution Control (8 Hours)**	
5.1	Control Devises for Particulate Contaminants: Gravitational settling, Centrifugal Collectors, Wet Collectors, Fabric filters and Electrostatic Precipitators (ESP)	3 Hours
5.2	Control Devises for Gaseous Contaminants: Adsorption, Absorption, Condensation, Combustion	2 Hours
5.3	Automobile Emission Control	1 Hour
5.4	Noise pollution - effects of noise on people-Noise control methods	2 Hours

CHT305	CHEMICAL REACTION ENGINEERING	CATEGORY	L	T	P	CREDIT
		PCC	3	1	0	4

Preamble: Sound knowledge in Reaction Engineering is very important for Chemical Engineers. The goal of this course is to develop a critical approach to chemical reactor design. This course would enable students to gain knowledge with respect to kinetics of homogeneous reaction, provide a foundation on deriving rate expressions for series, parallel, reversible reactions by the interpretation of batch reactor data, design of ideal reactors, design for single and for multiple reactions, non isothermal reactor design and incorporation of non ideality in reactor design.

Prerequisite: Basic knowledge in **C**hemical Process Principles & Chemical Engineering Thermodynamics

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

CO 1	Explain the principles of chemical kinetics and determine chemical kinetic parameters using batch reactor data.
CO 2	Design of chemical reactors under ideal conditions.
CO 3	Design of single and multiple reactions in ideal reactors.
CO 4	Design chemical reactors for non-isothermal operations.
CO 5	Design chemical reactors for non-ideal conditions.

Mapping of course outcomes with program outcomes

	PO1	PO2	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	2	3									
CO 3	3	2	3									
CO 4	3	2	3									
CO 5	3	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 (CO1): Explain the principles of chemical kinetics and determine chemical kinetic parameters using batch reactor data.

1. Device a mechanism for HBr reaction $H_2 + Br_2 \rightarrow 2HBr$

$$r_{HBr} = \frac{k[H_2][Br_2]^{\frac{1}{2}}}{1+k'\frac{[HBr]}{[Br_2]}}$$

2. The following data are obtained at 0^oC in a constant volume batch reactor using pure gaseous A for the reaction $A \rightarrow 2.5R$.

Time(min)	0	2	4	6	8	10	12	14	∞
pA, mm Hg	760	600	475	390	320	275	240	215	150

Find the rate equation which satisfactorily represents the data.

3. Find the overall order of the reaction from the following constant volume data using equimolar amount of hydrogen and nitric oxide.

$$2H_2 + 2NO \rightarrow N_2 + 2H_2O$$

Total pressure, mm of Hg	200	240	280	320	360
Half-life, sec	265	186	115	104	67

Course Outcome 2 (CO2): Design of chemical reactors under ideal conditions.

1. Establish the performance equation of a piston flow reactor, where the reaction is A → R which is a first order irreversible gas phase reaction.
2. An aqueous reaction A+ B→ products with known kinetics $-r_A$= 500 litre/ mol.min C_AC_B is to takes place in an experimental tubular reactor under the following condition. Volume of reactor V= 0.1 litre. Volumetric flow rate v = 0.05 litre/min. Concentration of the reactant feed $C_{A0}=C_{B0}$ = 0.01 mol/ litre.

a. What fractional conversion of reactants can be expected?
b. For the same conversion in part A what size of stirred tank reactors is needed.
c. What conversion can be expected in a MFR equal in size to a PFR.

3. An aqueous reactant stream (4 mol A/liter) passes through a mixed flow reactor followed by a plug flow reactor. Find the concentration at the exit of the plug flow reactor if in the mixed flow reactor C_A= 1 mol/liter. The reaction is second-order with respect to A, and the volume of the plug flow unit is three times that of the mixed flow unit.

Course Outcome 3 (CO3): Design of single and multiple reactions in ideal reactors.

1. Show that performance of a N equal size mixed flow reactor in series approaches to a performance equation of PFR. Assume reaction is first order
2. Obtain maximum concentration of R for a reaction A→R→S which occurs in mixed flow reactor.
3. Derive the performance equation of recycle reactor.

Course Outcome 4 (CO4): Design chemical reactors for non-isothermal operations.

1. An irreversible first order isomerisation reaction A→ R is carried out in liquid phase in a MFR. Rate constant k at 1650C is 0.7 hr^{-1}. Activation energy is 120000 J/mol. Heat of reaction is -350KJ/kg. Heat capacity of reactants and products are 1.95 KJ/kg K. Volumetric flow rate is 0.33 m^3 /hr. Feed temperature is 20^oC and conversion expected is 95%. Calculate the reactor size and temperature of the reaction mixture if the reactor is operated adiabatically.
2. The first order liquid phase reaction A→ R is carried out in a MFR. The concentration of reactant in the feed is 4 mol/l. Volumetric flow rate is 200 cm^3 /s. Density and specific heat of the reaction mixture are 1.2 g/cm^3 and 0.9 cal/g ^0C. The volume of the reactor is 10 lit. The reactor operates adiabatically. The feed enters at temperature 200^0C. Determine the possible temperatures and conversions for stable, adiabatic operation.
3. Derive the expression for conversion for a non isothermal adiabatic reaction starting from the energy balance equation.

Course Outcome 5 (CO5): Design chemical reactors for non-ideal conditions.

1. Discuss the importance of residence time distribution studies the design of chemical reactors. Also obtain the relation between C, E and F curves.
2. In a reactor liquid decomposing with rate $-r_A = kC_A$ where k=0.307 min^{-1}. Find the fraction of reactants unconverted in the real reactor of the same size. RTD study conducted in the reactor gives following data.

Time	0	5	10	15	20	25	30	35
Tracer output, conc. gm/litre of fluid	0	3	5	5	4	2	1	0

3. Discuss briefly on determination of E and F curve in a laminar flow reactor.

Model Question paper

QP CODE: **PAGES:3**

Reg No:_____ **Name :_____**

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
FIFTH SEMESTER B. TECH DEGREE EXAMINATION, MONTH & YEAR
Course Code: CHT305
CHEMICAL REACTION ENGINEERING

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

(2019-Scheme)

PART A

(Answer all questions, each question carries 3 marks)

1. Define molecularity and order of a chemical reaction.
2. The rate constants of a certain reaction are 1.6×10^{-3} and 1.625×10^{-2} $(s)^{-1}$ at 10°C and 30°C. Calculate the activation energy in KJ/mol.
3. Define space time and space velocity.
4. Explain on different types of ideal reactors.
5. Define an autocatalytic reaction. Give an example.
6. Explain on recycle ratio and recycle reactor.
7. List the steps involved in non-isothermal reactor design.
8. Write note on optimum temperature progression.
9. Explain the importance of RTD studies in non-ideal reactors.
10. List the properties of tracers in RTD studies.

PART B

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

Module I

11. a. Device a mechanism for HBr reaction $H_2 + Br_2 \rightarrow 2HBr$

$$r_{HBr} = \frac{k[H_2][Br_2]^{\frac{1}{2}}}{1+k'\frac{[HBr]}{[Br_2]}}$$

(7)

b. Derive the integral equation for a second order reaction with equimolar concentrations of the reactants. (7)

12. a. The half-life period for a certain first order reaction is 2.5×10^{3}s. Determine the time taken for ¼ of the reactant to be left behind. (7)

b. After 8 minutes in a batch reactor, reactant (C_{A0} = 1 mol/liter) is 80% converted; after 18 minutes, conversion is 90%. Find a rate equation to represent this reaction. (7)

Module II

13. a. Establish the performance equation of a piston flow reactor, where the reaction is A → R which is a first order irreversible gas phase reaction. (6)

b. An aqueous reactant stream (4 mol A/liter) passes through a mixed flow reactor followed by a plug flow reactor. Find the concentration at the exit of the plug flow reactor if in the mixed flow reactor C_A = 1mol/liter. The reaction is second-order with respect to A, and the volume of the plug flow unit is three times that of the mixed flow unit. (8)

14. a. Derive the performance equation for a batch reactor. (6)

b. The reaction of triphenyl methyl chloride (trityl) (A) and methanol (B),

$$A+B \rightarrow C+D$$

was carried out in a batch reactor and the following data were obtained.

Time, min	0	50	100	150	200	250	300
Concentration of A (mol/dm^3) x 10^3	50	38	30.6	25.6	22.2	19.5	17.4

The initial concentration of methanol was 0.5 mol/dm^3. Determine the reaction order with respect to triphenyl methyl chloride and the specific reaction rate constant. (8)

Module III

15. a. Show that performance of a N equal size mixed flow reactor in series approaches to a performance equation of PFR. Assume reaction is first order. (7)

b. Explain the method to determine the minimum size of two mixed reactors connected in series to achieve a specified conversion. (7)

16. a. Show that performance of a N equal size mixed flow reactor in series approaches to a performance equation of PFR. Assume reaction is first order. (7)

b. For a liquid feed (n=1, C_{A0} = 10 mol/liter) to a plug flow reactor with recycle of product (R = 2), 90% conversion is obtained. If the recycle stream is shut off, determine by how much this will lower the processing rate of feed to the same 90% conversion. (7)

Module IV

17. The first order liquid phase reaction A→ R is carried out in a MFR. The concentration of reactant in the feed is 4 mol/l. Volumetric flow rate is 200 cm3 /s. Density and specific heat of the reaction mixture are 1.2 g/cm3 and 0.9 cal/g 0C. The volume of the reactor is 10 lit. The reactor operates adiabatically. The feed enters at temperature 200C. Determine the possible temperatures and conversions for stable, adiabatic operation.

Take ΔHr= -46000 cal/mol and k= $1.8 \times 10^5 \exp(-12000/RT), s^{-1}$. (14)

18. a. Derive the expression for conversion for a non isothermal adiabatic reaction starting from the energy balance equation. (7)

b. Develop the expression to find the variations of equilibrium constants with temperature. **(7)**

Module V

19. a. Discuss the importance of residence time distribution studies the design of chemical reactors. Also obtain the relation between C, E and F curves. (10)

b. Explain causes for non ideality in real reactors (4)

20. a. In a reactor liquid decomposing with rate $-r_A=kC_A$ where k=0.307 min^{-1}. Find the fraction of reactants unconverted in the real reactor of the same size. RTD study conducted in the reactor gives following data

Time	0	5	10	15	20	25	30	35
Tracer output, conc. gm/litre of fluid	0	3	5	5	4	2	1	0

(8)

b. Discuss briefly on determination of E and F curve in a laminar flow reactor. (6)

Syllabus

Module 1(10 hours)

Overview of chemical reaction engineering. Classification of chemical reactions. Variables affecting the rate of reaction. Definition of reaction rate. Kinetics of homogeneous reaction. Concentration dependent term of rate equation. Kinetic models for Nonelementary reactions. Temperature dependent term of rate equation. Temperature dependency from Arrhenius law, Collision theory and transition state theory (no derivation).

Interpretation of batch reactor data-Evaluation of rate equation by integral and differential analysis for constant volume and variable volume system

Module 2 (8 hours)

Introduction to reactor design. Classification of reactors. Ideal reactors for a single reaction-Ideal batch reactor- Steady state mixed flow reactor-Steady state plug flow reactor. Holding time and space time for flow reactors.

Module 3 (12 hours)

Design for single reactions-Size comparison of single reactors- Multiple reactor systems-Plug flow reactor in series and parallel, equal sized mixed reactors in series, mixed flow reactors of different sizes in series, determination of the best system for a given conversion. Recycle reactor. Auto catalytic reactions. Design for multiple reactions, Reactions in parallel, contacting patterns for reactions in parallel.

Module 4 (7 hours)

Non isothermal reactor design - Temperature and pressure effects - single reactions-Heat of reaction from thermodynamic, heat of reaction and temperature, equilibrium

constants from thermodynamics. General graphical design procedure, optimum temperature progression. Heat effects: adiabatic operations and non-adiabatic operations Multiple Steady States in CSTR. Multiple reactions: Product distribution and temperature.

Module 5 (8 hours)

Non ideality in reactors- Basics of non ideal flow- Residence time distribution studies-C, E & F curves and their relationships. Conversion in non ideal reactors.

RTD in ideal reactors: Batch and plug flow reactors, single CSTR, Laminar flow reactor. Models for non ideal flow-dispersion model and tank in series model.

Text Books

1. Levenspiel Octave, "Chemical Reaction Engineering", John Wiley & Sons, Third Edition.
2. H Scott Fogler, "Elements of Chemical Reaction Engineering", Prentice Hall of India, Fifth Edition.
3. Smith J.M, "Chemical Engineering Kinetics," McGraw Hill.

Reference Books

1. James J Carberry, "Chemical &Catalytic Reaction Engineering", Mc Graw Hill.
2. K.G Denbigh& J.C.R Turner, "Chemical Reactor Theory- An Introduction", Cambridge University Press.
3. Lanny D Schmidt, "The Engineering of Chemical Reactions", Oxford University Press.
4. Ronald W. Missen, Charles A. Mims, Bradley A. Saville, „Introduction to Chemical Reaction Engineering and Kinetics", John Wiley & Sons
5. Hill C.G., An Introduction to Chemical Engineering Kinetics & Reactor Design, John Wiley

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Module I (10 Hours)**	
1.1	Overview of chemical reaction engineering. Classification of chemical reactions. Variables affecting the rate of reaction.	1
1.2	Definition of reaction rate. Kinetics of homogeneous reaction. Concentration dependent term of rate equation.	1
1.3	Kinetic models for Non-elementary reactions.	2
1.4	Temperature dependent term of rate equation. Temperature dependency from Arrhenius law, Collision theory and transition state theory (no derivation).	1
1.5	Interpretation of batch reactor data. Evaluation of rate equation by integral analysis for constant volume system	3
1.6	Evaluation of rate equation by differential analysis for constant volume system	1

1.7	Evaluation of rate equation by integral analysis for variable volume system	1
2	**Module II (8Hours)**	
2.1	Introduction to reactor design. Classification of reactors.	1
2.2	Ideal reactors for a single reaction- Ideal batch reactor	2
2.3	Steady state mixed flow reactor	2
2.4	Steady state plug flow reactor.	2
2.5	Steady state plug flow reactor.	1
3	**Module III (12 Hours)**	
3.1	Design for single reactions-Size comparison of single reactors	2
3.2	Multiple reactor systems- Plug flow reactor in series and parallel	1
3.3	Equal sized mixed reactors in series, mixed flow reactors of different sizes in series, determination of the best system for a given conversion.	3
3.4	Recycle reactor and Auto catalytic reactions.	3
3.5	Design for multiple reactions: Reactions in parallel, contacting patterns for reactions in parallel.	3
4	**Module IV (7 Hours)**	
4.1	Non isothermal reactor design - Temperature and pressure effects - single reactions- Heat of reaction from thermodynamic	1
4.2	Heat of reaction and temperature, equilibrium constants from thermodynamics.	1
4.3	General graphical design procedure, optimum temperature progression.	1
4.4	Heat effects: adiabatic operations	1
4.5	Heat effects: non-adiabatic operations	1
4.6	Multiple Steady States in CSTR.	1
4.7	Multiple reactions: Product distribution and temperature.	1
5	**Module V (8 Hours)**	
5.1	Non ideality in reactors. Basics of non ideal flow.	1
5.2	Residence time distribution studies-C, E & F curves and their relationships.	2
5.3	Conversion in non ideal reactors.	1
5.4	RTD in ideal reactors: Batch and plug flow reactors, single CSTR, Laminar flow reactor.	2
5.5	Models for non ideal flow-dispersion model and tank in series model.	2

CHT307	INSTRUMENTATION AND PROCESS CONTROL	CATEGORY	L	T	P	CREDIT
		PCC	3	1	0	4

Preamble: Sound knowledge in process control and instrumentation is very important for Chemical Engineers.Process control has become increasingly important in the process industries as a consequence of global competition, rapidly changing economic conditions, and more stringent environmental and safety regulations. Proper application of process control improves the safety and profitability of a process, while maintaining consistently the desired product quality.

This course would enable students to gain knowledge on application of Laplace transforms, frequency response etc. for obtaining transient response of first order systems, second order systems, controllers, feedback industrial control systems and their stable and safe range of operation.This course introduces students to some modern methods and tools used for measuring variables in a process industry which are essential for proper control and functioning of all equipments and processes

Prerequisite: Basic engineering mathematics and concepts of Laplace transforms

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

CO 1	Categorize measuring instruments for industrial applications and illustrate instrumentation for temperature, pressure, flow, level, composition and pH.
CO 2	Apply Laplace transforms to solve linear differential equations and to obtain the transfer function related to first order systems.
CO 3	Develop the response of linear open loop second order systems and systems in series for various forcing functions.
CO 4	Describe various types of controllers and analyse servo and regulatory problems of closed loop systems by using transient response.
CO 5	Analyze the stability of linear systems by using analytical and graphical methods. Design controllers.

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								
CO 2	3	3	3	3								
CO 3	3	3	3	3								
CO 4	3	3	3	3								
CO 5	3	3	3	3								

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	10
Understand	20	20	30
Apply	20	20	60
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. Suggest a method for the measurement of pressure above 10,000kg/cm^2. Write its working principle

Course Outcome 2 (CO2)

1. Solve the following equation using Laplace transforms:

$$25\frac{d2x}{dt2} + x = 1 \text{ with x (0) =0 and x'(0)=0.}$$

2. Find the final value of y(t) for the transfer function

$$y(s) = \frac{1}{s(s^3 + 3s^2 + 3s + 1)}$$

Course Outcome 3(CO3):

1. Explain each term with its significance in process control: overshoot, decay ratio, rise time, and settling time.

2. Assume thermometer in a thermo well as an under damped system; obtain the expression for response of thermometer when subjected to a step change in the surrounding temperature.

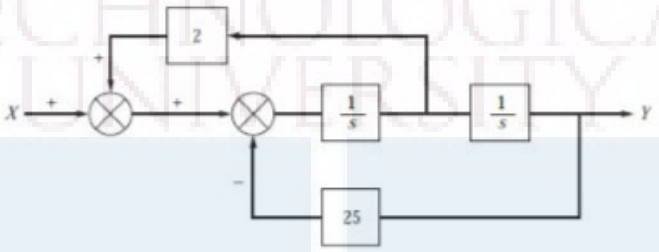
Course Outcome 4 (CO4):

1. Sketch the input and output functions for the following controller actions:

a) Ramp input to a derivative controller

b) Step input to a PI controller

2. Derive the transfer function Y/X for the control system shown in figure below.



Course Outcome 5 (CO5):

1. Describe Ziegler-Nichols tuning methodology.
2. State Bode stability criterion.
3. Determine the stability of the characteristic equation by Routh test.

$$2s^4 + s^3 + 3s^2 + 4s + 10 = 0$$

Model Question paper

QP CODE: **PAGES:3**

Reg No:_____Name :_____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIFTH SEMESTER B. TECH DEGREE EXAMINATION,MONTH & YEAR

Course Code: CHT 307

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

(2019-Scheme)

PART A

(Answer all questions, each question carries 3 marks)

1. Suggest any 2 instruments each for low, medium and high pressure measurement
2. Describe the principle and working of radiation pyrometer
3. Sketch the following function

   f(t)=u(t)-2u(t-1)+u(t-3)
4. Determine the final value of the function

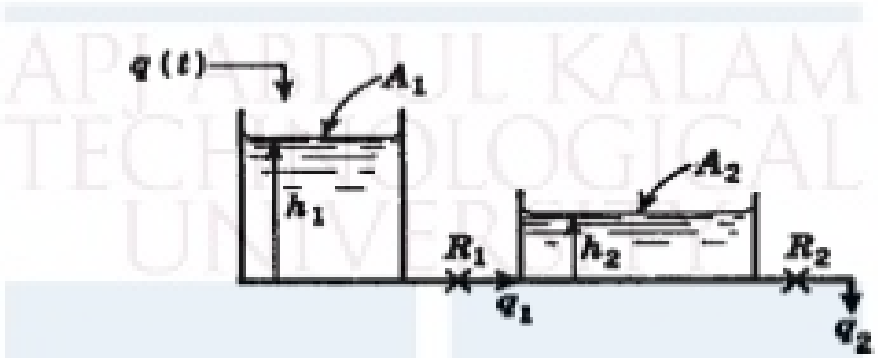
$$f(s) = \frac{(s+4)}{s(s-1)(s-2)(s+3)}$$

5. A step change of magnitude 1 unit is imparted to the input to a system of transfer function

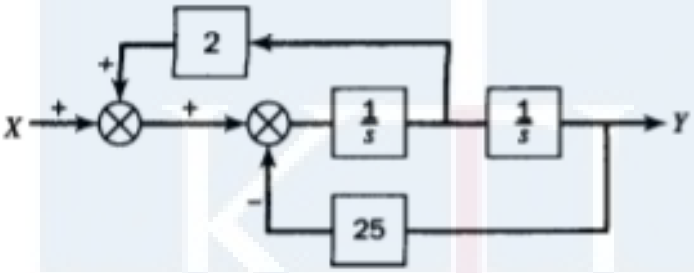
$$\frac{Y(s)}{X(s)} = \frac{1}{s^2 + s + 1}$$

Determine overshoot, Decay ratio, Rise time and Period of oscillation if the time is measured in seconds.

6. Determine the transfer function $H_2(s)/Q(s)$ for the liquid level system show below: Resistances $R_1$and R_2 are linear



7. Determine$\frac{C(s)}{R(s)}$.



8. Explain servo and regulator problem in control systems with suitable examples.
9. Explain Routh criterion of stability.
10. State Bode stability criterion.

PART B

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

Module I

11. a) With an example explain the functional elements of an instrument. (8)

b) explain static and dynamic characteristics of instruments. (6)

12. a) Illustrate the laws of thermoelectricity. Describe the k thermocouple and its application (8)

b). explain different class of instruments used for flow measurement (6)

Module II

13.a) State initial and final value theorem. (2 marks)

b) The function f(t) has the Laplace transform

$$f(s) = \frac{1 - 2e^{-s} + e^{-2s}}{s^2}$$

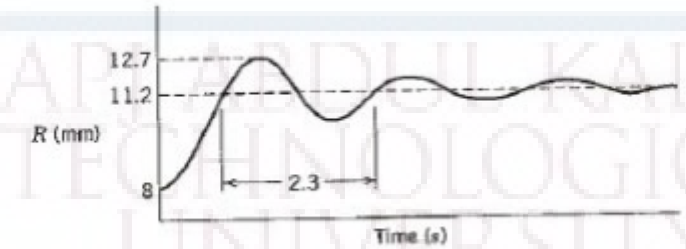
Obtain the function f(t) and graph f(t). (5 marks)

c) Solve the following by using Laplace transform.

$\frac{d^2x}{dt^2} + \frac{dx}{dt} + x = 1, x(0) = x'(0) = 0$ (7 marks)

Module III

14. a) A step change from 15 to 31 psi in actual pressure results in the measured response from a pressure-indicating element shown in figure below.

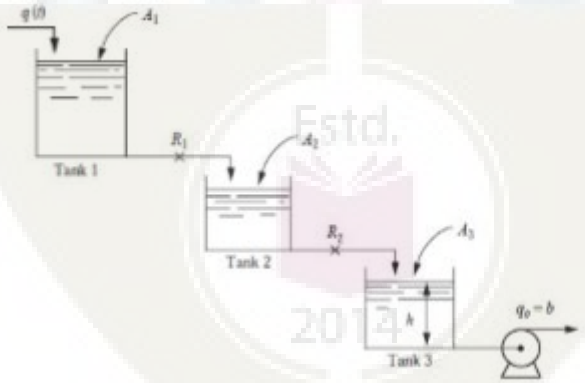


Assuming second order dynamics, determine (i) process gain, Kp, (ii) overshoot, (iii) decay ratio, (iv) damping coefficient, ζ and (v) time constant, τ. write the approximate second order transfer function. (9 marks)

b) Derive expression for H(s)/Q(s) for a non-interacting system. (5 marks)

15. a) A thermometer having a time constant of 1 min is initially at 50°C. It is immersed in a bath maintained at 100°C at t = 0. Determine the temperature reading at 1.2 min. (5 marks)

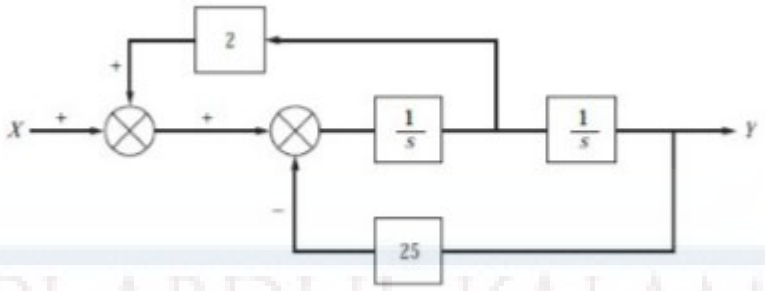
b)Determine the transfer function H (s)/Q (s) for the liquid-level system shown in fig. below Resistances R1 and R2 are linear. The flow rate from tank 3 is maintained constant at b by means of a pump; i.e., the flow rate from tank 3 is independent of head h. The tanks are non-interacting. (9 marks)



Module IV

16. a. List out the different types of controllers with its corresponding transfer function. (5 marks)

b. Derive the transfer function Y/X for the control system shown in figure below. (9 marks)



17. a. A feedback control system consists of a process and proportional controller. The transfer function of the process is

$$Gp(s) = \frac{3}{(10s+1)(5s+1)}$$

i. Calculate the value of the P-controller gain that will result in critically damped behaviour.

ii. If the controller gain obtained in (a) is used what will be the offset for a unit step change in set point.

iii. For a unit step change in set point, what will be controller gain to result an offset of 10%? (9 marks)

b. A unit step change in error is introduced into a PID controller. If K_c=10. Obtain the response of the controller. (5 marks)

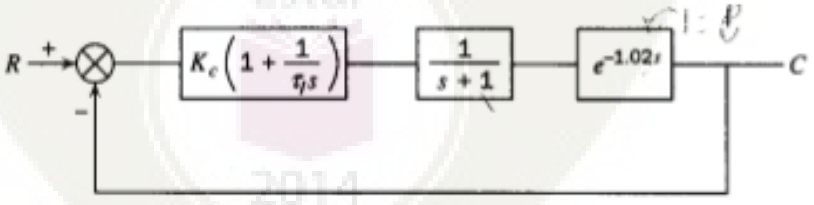
Module V

18. a. Obtain the Bode plot for the following open loop transfer function.

$$G(s) = \frac{100}{(10s+1)(s+1)}$$

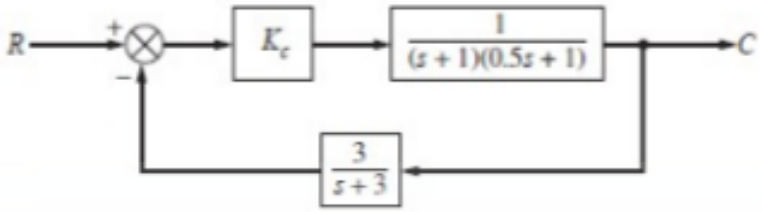
Determine the cross over frequency (10 marks)

b.Using the Ziegler-Nichols rules, determine K_c, and τ_I for the control system shown in Fig.



(4 marks)

19.a) Write the characteristic equation and construct the Routh array for the control system shown in figure.



Determine the stability of the system for (a) Kc = 9.5, (b) Kc = 11, and (c) Kc = 12. (9 marks)

b. Explain the procedure to compute phase and gain margins from Bode plot. (5 marks)

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APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
KTU
Estd. 2014

Syllabus

Module 1 (8 Hours)

Performance characteristics of measuring instruments: static and dynamic characteristics of measuring instrument. List of instruments for temperature, pressure, flow and level measurement. Detailed study of mercury in glass thermometer, thermocouples, thermistors, resistance thermometer, radiation pyrometer, bourden gauge, ionization meter, piezoelectric manometer, orifice meter, coriolis meter, differential pressure level measurement and high-pressure measurement. Conductivity meters, solid level detectors.

Module 2 (8 Hours)

Laplace transform - transform of simple functions – derivatives and integral - properties of Laplace transforms - final value theorem - initial value theorem - transition of transforms and functions – examples - inversion by partial fraction - solution of differential equations, Linear open loop systems - mercury thermometer, liquid level process: single tank.

Module 3 (8 Hours)

Interacting and non-interacting types, manometer - response of these towards different types of forcing functions: step and sinusoidal functions. Control valves- types, working principle, selection. P, PI and PID Controllers - basic principles and transfer functions

Module 4 (11Hours)

Closed loop system – feedback control- servo and regulator problems -block diagram development –Block diagram reduction-Transient response of simple control systems - step response and offset.

Introduction to stability of linear systems - Routh- Hurwitz criterion for stability -Root locus technique-plotting root locus diagram.

Module 5 (10 Hours)

Introduction to frequency response - substitution rule –. Bode diagram for first order systems - first order systems in series - second order systems - bode stability criterion, gain margin and phase margin.

Controller tuning- Ziegler-Nichol’s method - comparison of closed loop responses for different controller settings.

Text Books

1. Jain R K, Mechanical and Industrial measurements, Khanna publishers
2. Patranabis D, Principles of Industrial Instrumentation, Tata- McGraw Hill.
3. Coughanewr D.P., Process Systems Analysis& Control, McGraw Hill
4. Stephanopoulose G., Chemical Process Control, An Introduction to Theory & Practice, Prentice Hall of India
5. Dale E. Seborg, Thomas F. Edgar and Duncan A. Mellichamp, Process Dynamics and Control, John Wiley & Sons Inc. Second Edition.

Reference Books

1. Ernest O Doeblin, Measurement systems, Application and Design, McGraw Hill
2. Donald P Eckman, Industrial Instrumentation, CBS Publishers and Distributors, New Delhi
3. Eckman D.P., Principles of Industrial Process Control, John Wiley & Sons Inc, NY (1946)
4. Harriot P., Process Control, Tata McGraw Hill
5. Ceaglske N.H., Automatic Process Control for Chemical Engineers, John Wiley & Sons, NY, 1956

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Module I (8 hours)**	
1.1	Performance characteristics of measuring instruments: static and dynamic characteristics of measuring instrument.	1
1.2	List of instruments for temperature, pressure, flow and level measurement -range and principle	1
1.3	List of instruments for temperature, pressure, flow and level measurement-their selection wrt. requirements	1
1.4	Detailed study of mercury in glass thermometer, thermocouples, thermistors.	1
1.5	Resistance thermometer, radiation pyrometer,	1
1.6	bourden gauge, ionization meter, piezoelectric manometer,	1
1.7	orifice meter, coriolis meter, differential pressure level measurement	1
1.8	High pressure measurement. Conductivity meters, solid level detectors.	1
2	**Module II (8 hours)**	
2.1	Laplace transform - transform of simple functions	1
2.2	derivatives and integral	1
2.3	properties of Laplace transforms - final value theorem - initial value theorem	1
2.4	transition of transforms and functions – examples	1
2.5	inversion by partial fraction	1
2.6	solution of differential equations	1
2.7	Linear open loop systems - mercury thermometer	1
2.8	liquid level process: single tank.	1
3	**Module III (8 hours)**	
3.1	Interacting and non-interacting types	2
3.2	manometer	1
3.3	response of these towards different types of forcing functions: step and sinusoidal functions	2
3.4	Control valves- types, working principle, selection	1
3.5	P, PI and PID Controllers - basic principles and transfer functions	2
4	**Module IV (11 hours)**	

4.1	Closed loop system – feedback control- servo and regulator problems	3
4.2	block diagram development –	1
4.3	Block diagram reduction	1
4.4	Transient response of simple control systems - step response and offset.	2
4.5	Introduction to stability of linear systems - Routh- Hurwitz criterion for stability	2
4.6	Root locus technique-plotting root locus diagram	2
5	**Module V (10 hours)**	
5.1	Introduction to frequency response - substitution rule.	2
5.2	Bode diagram for first order systems	2
5.3	first order systems in series	1
5.4	second order systems - bode stability criterion, gain margin and phase margin	2
5.5	Controller tuning- Ziegler-Nichol's method	1
5.6	comparison of closed loop responses for different controller settings.	2

CHL331	HEAT TRANSFER OPERATIONS LAB	CATEGORY	L	T	P	CREDIT
		PCC	0	0	3	2

Preamble:
This course helps the students to understand the principles of various modes of heat transfer through experimental procedures.This practical course familiarizes the students the operations and working of various heat transfer equipment.

Prerequisite:
Theoretical knowledge of Process Heat Transfer.

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

CO 1	Experiment with various modes of heat transfer.
CO 2	Evaluation the heat transfer coefficients.
CO 3	Determine the rate of heat transfer in various modes of heat transfer.
CO 4	Analyse the working of heat transfer equipments.
CO 5	Interpret and present the experimental data meaningfully.
CO 6	Develop teamwork 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								3			
CO 2		3							3			
CO 3		3	2						3			
CO 4	3								3			3
CO 5				3					3	3		
CO 6									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	:15Marks
(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.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Find the thermal conductivity of insulating material for lagged pipe apparatus.
2. Find the theoretical and experimental heat transfer coefficient for natural convection.
3. Find the radiation constant and emissivity of heated brass cylinder.

Course Outcome 2 (CO2)

1. Plot the heat transfer coefficient versus tube length for the given natural convection apparatus.
2. Determine the convective heat transfer coefficient of forced convection.
3. Find the overall heat transfer coefficient for the shell and tube heat exchanger.

Course Outcome 3(CO3):

1. Determine Stefan Boltzmann constant using the given apparatus.
2. Find the critical radius of insulation.
3. Determine the emissivity of iron sphere.

Course Outcome 4 (CO4):

1. Find LMTD, overall heat transfer coefficient and effectiveness of the counterflow heat exchanger.
2. Find LMTD, overall heat transfer coefficient and effectiveness of the shell and tube heat exchanger.

3. Compare the effectiveness of shell and tube heat exchanger using LMTD and NTU method.

Course Outcome 5 (CO5):

1. Compare experimental and theoretical heat transfer coefficient for natural convection.
2. Find experimental and theoretical heat transfer coefficient for forced convection.

Course Outcome 6 (CO6):

1. Compare the LMTD for parallel and counterflow heat exchanger by performing experiment.
2. Explain the various parts of a shell and tube heat exchanger.
3. Demonstrate the working of a single effect evaporator.

LIST OF EXPERIMENTS (Minimum of 10 experiments are mandatory)

1. Heat Transfer by Natural Convection
2. Heat Transfer by Forced Convection
3. Thermal conductivity of Metal Rod
4. Heat transfer through Composite Wall
5. Heat transfer in Double pipe heat exchanger
6. Heat Transfer in Shell and Tube Heat Exchanger
7. Emissivity Measurement Apparatus
8. Heat Transfer in Fins
9. Unsteady State Heat Transfer
10. Heat Transfer in Agitated Vessels
11. Combined Convection and Radiation Heat Transfer
12. Radiation Heat Transfer
13. Drop and Filmwise Condensation
14. Determination of Critical Radius of Insulation
15. Any other experiment related to different modes of heat transfer with and without change of phase.

Reference Books

1. Datta B.K., Heat Transfer: Principles and Applications, Prentice Hall India.
2. McCabe W.L., Smith J.C. &Harriot P., Unit Operations in Chemical Engineering, McGraw Hill.
3. Hollman J.P., Heat Transfer, McGraw Hill.
4. R C Sachdeva, Fundamentals of Engineering Heat and Mass Transfer, New age International Publishers.

CHL333	PROCESS CONTROL LAB	CATEGORY	L	T	P	CREDIT
		PCC	0	0	3	2

Preamble: This laboratory course is designed to learn real time dynamics and controlling of process parameters such as temperature, pressure, level and concentration in simple basic systems.

Prerequisite: Basic knowledge in Instruments, Process dynamics and Control

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

CO 1	Sketch and use the calibration graphs of temperature and pressure measuring instruments
CO 2	Test the dynamics of first order systems like temperature, level and mixing processes
CO 3	Test the dynamics of second order systems such as thermometer with thermowell, tanks in series and U-tube manometer
CO 4	Test the characteristics of pneumatic control valves
CO 5	Experiment on the control of temperature, flow and level processes
CO 6	Experiment on controller tuning

Mapping of course outcomes with program outcomes(High-3, Medium-2, Low -1)

	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	1		1
CO 2	3	3		2	2				2	1		1
CO 3	3	3		3	3				2	1		1
CO 4	3	2							2	1		1
CO 5	3	3		3	3				2	1		1
CO 6	3	3	3	3	3				2	1		1

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	: 15Marks
(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.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Draw the calibration curve of the given thermocouple and find its accuracy using the curve
2. Draw the calibration curve of the given U-tube manometer
3. Draw the calibration curve of the given pressure transducer

Course Outcome 2 (CO2)

1. Sketch the step response curve of the given thermocouple and find its time constant
2. Sketch the step response curve of the given bare thermometer and find its time constant
3. Sketch the step response curve of a single tank liquid level system and find its time constant
4. Sketch the impulse response curve of a stirred tank liquid mixing system and find its time constant

Course Outcome 3(CO3):

1. Sketch the step response curve of a two-tank non-interacting liquid level system and compare it with the theoretical response
2. Sketch the step response curve of a two-tank interacting liquid level system and compare it with the theoretical response

3. Sketch the step response curve of the given thermometer with thermowell and find the apparent time constants

Course Outcome 4 (CO4):

1. 1. Plot the installed characteristics of equal percentage pneumatic control valve
2. 2. Plot the inherent characteristics of linear control valve
3. 3. Plot and compare the inherent characteristics of quick opening control valve and linear control valve

Course Outcome 5 (CO5):

1. Obtain the closed loop response of the proportional controller for level control
2. Obtain the closed loop response of the proportional integral (PI) controller for Temperature control
3. Obtain the closed loop response of the proportional integral derivative (PID) controller for Temperature control

Course Outcome 6 (CO6):

1. Obtain the gain of the proportional controller for level control
2. Obtain the gain and integral time of the proportional integral (PI) controller for Temperature control
3. Obtain the controller parameters ofthe proportional integral derivative (PID) controller for level control

LIST OF EXPERIMENTS

Minimum **eight experiments** are mandatory in this lab course and shall be based on the following concepts:

- Calibration of instruments
- Dynamic response of typical first and second-order systems.
- Dynamic response of systems in series.
- Response of closed loop systems with different control configurations.
- Tuning of Controllers

Sl No.	Name of Experiment	No. of Hours
01	Dynamic Response of Mercury in Glass Thermometer	3 Hrs
02	Dynamic Response of U-tube Manometer	3 Hrs
03	Dynamics of thermocouple	3 Hrs
04	Dynamics of liquid level system - single tank	3 Hrs

05	Dynamics of liquid level system - non-interacting tanks in series		3 Hrs
06	Dynamics of liquid level system - interacting tanks in series		3 Hrs
07	Dynamic Response of Thermometer in Thermowell		3 Hrs
08	Dynamics of mixing process		3 Hrs
09	Pressure Control Trainer (Any four experiments of among the sub-list mandatory)	a) Study of open loop response (manual control) b) Study of on/off controller. c) Study of proportional controller d) Study of proportional integral controller e) Study of proportional derivative controller f) Study of proportional integral derivative controller g) Tuning of controller (open loop method) h) Tuning of controller (closed loop method) i) Tuning of controller (using auto tuning method) j) Study stability of the system (Bode plot)	3 Hrs
10	Temperature Control Trainer (Any four experiments of among the sub-list mandatory)	a) Study of open loop response (manual control) b) Study of on/off controller. c) Study of proportional controller d) Study of proportional integral controller e) Study of proportional derivative controller f) Tuning of controller (open loop method) g) Tuning of controller (closed loop method) h) Tuning of controller (using auto tuning method) i) Study stability of the system (Bode plot)	3 Hrs
11	Level Control Trainer (Any four experiments of among the sub-list mandatory)	a) Study of open loop response (manual control) b) Study of on/off controller. c) Study of proportional controller d) Study of proportional integral controller e) Study of proportional derivative controller f) Study of proportional integral derivative controller g) Tuning of controller (open loop method) h) Tuning of controller (closed loop method) i) Tuning of controller (using auto tuning method) j) Study stability of the system (Bode plot)	3 Hrs

12	Flow Control Trainer (Any four experiments of among the sub-list mandatory)	a) Study of open loop response (manual control) b) Study of on/off controller. c) Study of proportional controller d) Study of proportional integral controller e) Study of proportional derivative controller f) Study of proportional integral derivative controller g) Tuning of controller (open loop method) h) Tuning of controller (closed loop method) i) Tuning of controller (using auto tuning method) j) Study stability of the system (Bode plot)	3 Hrs
13	Calibration of Thermocouples		3 Hrs
14	Control Valve characteristics		3 Hrs
15	I to P and P to I Converter characteristics		3 Hrs
16	Control system design using MATLAB-Simulink **OR**Scilab-Xcos		3 Hrs
17	Any other experiments related to process dynamics and control on the basis of the course CHT 307 Instrumentation and Process Control		3Hrs

Reference Books

1. Albert C.L. &Coggen D.A., *Fundamentals of Industrial Control*, ISA
2. Ceaglske N.H., *Automatic Process Control for Chemical Engineers,* John Wiley & Sons Inc
3. Coughanowr D.R., *Process System Analysis & Control*, McGraw Hill
4. Eckman D.P., *Principles of Industrial Process Control*, John Wiley& Sons Inc
5. Harriot P., *Process Control*, Tata McGraw Hill
6. Stephanopoulose G., *Chemical Process Control- An Introduction to Theory & Practice*, Prentice Hall of India
7. Tsai T.H., Lane J.W. & Lom C.S., *Modern Control Techniques for the Processing Industries*, Marcel Dekker

SEMESTER V

MINOR

CHT381	OCCUPATIONAL HEALTH & INDUSTRIAL HYGIENE	CATEGORY	L	T	P	CREDIT
		VAC	3	1	0	4

Preamble: The purpose of this course is to place in perspective the many factors involved in relating various industrial and occupational factors to health and the rationale upon which the practice of industrial hygiene is based, including the anticipation, recognition, evaluation, and control of workplace stresses, the biological responses to these stresses, the body defence mechanisms involved, and their interrelationships.

Prerequisite: Nil

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

CO 1	Identify the existence of occupational safety and health hazardsin work places and explain the importance of industrial hygiene.
CO 2	Analyse and apply industrial hygiene strategies with respect to chemical, biological, and physical hazards.
CO 3	Identify occupational health and industrial hygiene standards, testing systems and monitoring techniques.
CO 4	Explain health-affecting agents, factors and stressors and how they relate to typical industrial processes, unit operations, and tasks.
CO 5	Apply the relevant regulatory and national consensus standards and legal threshold limit values around hazardous exposure.

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					3	3					1
CO 2	1	1				3	3					1
CO 3	1					3	3					1
CO 4	1					3	3					1
CO 5	1					3	3					1

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	20
Understand	10	10	20
Apply	20	20	40
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): Identify the existence of occupational safety and health hazards in work places and explain the importance of industrial hygiene.

1. Explain the term occupational diseases. Group them under physical agent, chemical agent & biological agent.
2. Define Occupational Health. Enlist occupational diseases due to metals & dusts.
3. Define Occupational epidemiology and write the applications with examples.

Course Outcome 2 (CO2): Analyse and apply industrial hygiene strategies with respect to chemical, biological, and physical hazards.

1. Explain various occupational diseases caused by metals, dusts, fumes and chemical compound.
2. Compare various routes of entry of toxicants in to the human body.
3. Define the term ergonomics. Explain its Application.

Course Outcome 3(CO3): Identify occupational health and industrial hygiene standards, testing systems and monitoring techniques.

1. Define Pneumoconiosis as per International Labour Organization. Name the various types Pneumoconiosis.
2. Define permissible exposure limit, threshold limit value, lethal dose and lethal concentration.
3. Write a note on Occupational Health Standards.

Course Outcome 4 (CO4): Explain health-affecting agents, factors and stressors and how they relate to typical industrial processes, unit operations, and tasks.

1. Write a short note on "Safety Measures for Electrical Work".
2. Explain the significance of knowing MSDS in handling Chemicals. "Chemical Substance affects the bodies" - Elaborate with examples.
3. Briefly explain the effects on health due to cold and heat radiation and laser beams and also to explain their control measures.
4. Explain the health effects by exposing of ammonia, halogenated gases, hydro carbons gases and fumes like NO_X, SO_X, Cl_2, HCl and H_2S.

Course Outcome 5 (CO5): Apply the relevant regulatory and national consensus standards and legal threshold limit values around hazardous exposure.

1. Describe the significance of Threshold Limit Value (TLV).
2. Explain: (i) MSDS (ii) EHS (iii) LD50.
3. Explain: (i) The Workmen's Compensation Act, (ii) OHSAS18001, (iii) Mines Act.1952 and (iv) The Factories Act, 1948.

Model Question paper

QP CODE: **PAGES:**

Reg. No: _____Name: _____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIFTH SEMESTER B. TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: CHT 381

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

OCCUPATIONAL HEALTH & INDUSTRIAL HYGIENE

PART – A

Answer All the Questions (10 x 3 = 30)

1. Name any three organizations in the field of occupational health.
2. List down the advantages of checklists while carrying out an occupational health audit.
3. Identify any three types of voice measurement techniques.
4. Describe the physical effect of whole-body vibration.
5. A large chemical spillage is to be cleaned with a flammable solvent manually.Write the possible health effects upon exposure to the solvent.
6. Identify the routes through which toxicants enter the biological systems.
7. Describe how the body parts prevent dust from entering the body.

8. Explain the method to identify a dust problem in a workplace.
9. Write shot note on TLVs.
10. Give reasons why PPE should be considered only after other control measures.

PART – B

Answer one full question from each module (5 x 14 = 70)

Module 1

11. Describe the purpose of different sections of an organization's health and safety policy. (14 marks)

OR

12. Explain the main components of a health and safety management system. (14 marks)

Module 2

13. a) Explain types of engineering controls that can be used to reduce noise in work place. (4 Marks)

    b) Explain different types of non-ionizing radiations also describe the health effects that may be caused by non-ionizing radiation (10 Marks)

OR

14. a) List common hazards from electricity. (6 Marks)

    b) Write and explain the possible effect of electricity on the body. (8 Marks)

Module 3

15. a) Employees can be exposed to chemical agents in workplace. List and explain different forms of chemical agents. (7 Marks)

    b) Describe the control measures that could be used to reduce the risk of infection from biological organism. (7 Marks)

OR

16. a) Explain the factors influencing the intensity of toxic action in human body. (6 Marks)

    b) Explain the different control strategies that could be implemented for toxic vapour and mist exposure. (8 Marks)

Module 4

17. Explain the safety precautions that should be implemented to avoid occupational asthma. (14 Marks)

OR

18. Define the term 'ergonomics'. Outline the factors that should be considered in anergonomic assessment of a digital control system workstation. (14 Marks)

Module 5

19. Explain different assessment techniques for air borne contaminants in a workplace. (14 Marks)

OR

20. You are assigned to prepare MSDS for a solvent. Write a note on the different information required to prepare this MSDS. Also find out the applications of MSDS. (14 Marks)

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Syllabus

Module 1(9 Hours)

Overview of Occupational Health: Introduction, History of Occupational Health, Occupational Health Policy in India, National and International Organizations in the field of occupational health, OHS: its principles & functions, Diagnosis of Occupational Diseases, Occupational health hazards and its preventive measures - occupational health audit and occupational Health Survey, Occupational epidemiology – purpose, approach and significance. Occupational Safety and Health Legislations – ILO Conventions, NIOSH, EPA, The Workmen's Compensation Act, OHSAS18001, Mines Act.1952, The Factories Act, 1948, Water (Prevention & control of pollution) Act, 1974 and Air (Prevention & control of pollution) Act, 1981.

Module 2(8 Hours)

Physical Health Hazards & its Management: Noise - compensation aspects, noise exposure regulation, properties of sound, occupational damage, risk factors, sound measuring instruments, noise control program, industrial audiometry, hearing conservation programs. Vibration - types, effects, instruments, surveying procedure, permissible exposure limit.Ionizing radiation - types, effects, monitoring instruments, control programs, OSHA standard. Non-ionizing radiations - effects, types, radar hazards, microwaves and radio-waves, lasers, TLV. Other physical health hazards in industry including heat, cold,electricity, light, barometric pressure and electro-magnetic field.

Module 3(10 Hours)

Chemical Health Hazards & its Management: Toxicokinetic – absorption, metabolism, retention, entoxification, detoxification, excretion of toxic chemicals (xenobiotics), acute verses chronic effects, relation between work place exposure and health effects. Metals in Industry - Arsenic & its compounds, Cadmium & its compounds, Chromium & its compounds, Cobalt & its compounds, Fluoride, Lead & its compounds, Manganese, Mercury, Phosphorus and Uranium. Gas, Vapor & Mist in Industry - Carbon Monoxide, Hydrogen Cyanide, Hydrogen Sulphide, Chlorine, Phosgene, Ammonia. Organic Chemicals – Benzene and Toluene. Pesticides & its toxicity.

Biological Hazards & its Management: Occupational Zoonotic Diseases.

Module 4(9 Hours)

Occupational Lung Diseases & its Diagnosis: Occupational Lung Diseases like Silicosis, Asbestosis, Coal Worker's Pneumoconiosis, Mixed Dust Fibrosis. Occupational Asthma (i.e.Byssinosis) & Extrinsic Allergic Alveolitis (like Bagassosis).Pulmonary Function Test.ILO Radiograph on Pneumoconiosis .Notifiable Occupational Diseases in India as per Factories Act, 1948. ILO list of Occupational Diseases.

Ergonomics & Work Physiology: Introduction to Ergonomics, application of ergonomics in industry, Stress and performance, anthropometry and work physiology, physical fitness test in industry, fatigue, VO_2Max, workload.

Module 5(9 Hours)

Industrial Hygiene: Introduction, principles and practices. Chemical Stresses/Agents at workplace. Assessment of airborne contaminants in the work environment – including various methods of air-sampling for area and personal monitoring. Concept of thresh-hold limit values/permissible limits of exposure and recommended exposure limits in industry. Concept of air-borne contaminants by substitution, isolation, enclosure, wet methods, industrial ventilation – dilution and local exhaust systems. Material Safety Data Sheets (MSDS). Biological monitoring and its applications. Selection, use, care and maintenance of Respiratory & Non-respiratory Personal Protective Equipment.

Text Books:

1. Barbara A. Plog, Patricia J. Quinlan**,** Fundamentals of Industrial Hygiene (5th edition), National Safety Council Chicago,5th Edition (2001).
2. John J. Talty, Industrial Hygiene Engineering-Recognition, Measurement, Evaluation and Control, Noyes Data Corporation, USA (1999).
3. Frank R. Spellman, Industrial Hygiene Simplified-A Guide to Anticipation, Recognition, Evaluation, and Control of Workplace Hazards-Government Institutes (2006).
4. Daniel A. Crowl, Joseph F. Louvar, Chemical Process Safety: Fundamentals with Applications, Prentice Hall (2011).
5. Sam Mannan, Lees' Loss Prevention in the Process Industries: Hazard Identification, Assessment and Control, Vol: 1-3-Butterworth-Heinemann (2004).

Reference Books

1. Patty, "Industrial Hygiene and Toxicology", Wiley Inter science, 1979.
2. Industrial Ventilation Manual, American Conference of Government Industrial Hygienists, 1993
3. Encyclopaedia of "Occupational Health and Safety", Vol.I and II, published by international Labour Office, Geneva, 1985.
4. Clayton & Clayton, Patty`s"Industrial Hygiene and Toxicology", Vol.I, II and III, Wiley Inter science, 1986
5. Encyclopaedia of Occupational Safety and Health" ILO Publication, 1980.
6. Terry Brimson,"The health and safety guide", Mc Graw Hill Book Company, Europe-England.
7. Peter, P.,"Occupational health hazards"- A practical Industrial Guide (Second Edition).
8. "Safety and good house-keeping", NPC, New Delhi, 1985.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Overview of Occupational Health (9 Hours)**	
1.1	Introduction, History of Occupational Health, Occupational Health Policy in India, National and International Organizations in the field of occupational health	2
1.2	OHS: its principles & functions, Diagnosis of Occupational Diseases	1

1.3	Occupational health hazards and its preventive measures - occupational health audit and occupational Health Survey	1
1.4	Occupational epidemiology – purpose, approach and significance.	1
1.5	Occupational Safety and Health Legislations – ILO Conventions, NIOSH, EPA, The Workmen's Compensation Act	2
1.6	Occupational Safety and Health Legislations – OHSAS-18001, Mines Act.1952, The Factories Act, 1948	1
1.7	Occupational Safety and Health Legislations – Water (Prevention & control of pollution) Act, 1974 and Air (Prevention & control of pollution) Act, 1981.	1
2	**Physical Health Hazards & its Management (8 Hours)**	
2.1	Noise - compensation aspects, noise exposure regulation, properties of sound, occupational damage.	1
2.2	Noise -risk factors, sound measuring instruments, noise control program, industrial audiometry, hearing conservation programs.	1
2.3	Vibration - types, effects, instruments, surveying procedure, permissible exposure limit.	1
2.4	Ionizing radiation - types, effects, monitoring instruments, control programs, OSHA standard.	1
2.5	Non-ionizing radiations - effects, types, radar hazards, microwaves and radio-waves, lasers, TLV.	1
2.6	Other physical health hazards in industry including heat, cold, electricity, light, barometric pressure and electro-magnetic field.	3
3.1	**Chemical Health Hazards & its Management (7 Hours)**	
3.1.1	Toxicokinetic – absorption, metabolism, retention, entoxification, detoxification	1
3.1.2	Excretion of toxic chemicals (xenobiotics), acute verses chronic effects, relation between work place exposure and health effects.	2
3.1.3	Metals in Industry - Arsenic & its compounds, Cadmium & its compounds, Chromium & its compounds, Cobalt & its compounds, Fluoride, Lead & its compounds, Manganese, Mercury, Phosphorus and Uranium.	2
3.1.4	Vapor & Mist in Industry - Carbon Monoxide, Hydrogen Cyanide, Hydrogen Sulphide, Chlorine, Phosgene, Ammonia.	1
3.1.5	Organic Chemicals – Benzene and Toluene.Pesticides & its toxicity.	1
3.2	**Biological Hazards & its Management (3 Hours)**	
3,2,1	Occupational Zoonotic Diseases	3
4.1	**Occupational Lung Diseases & its Diagnosis (5 Hours)**	
4.1.1	Occupational Lung Diseases like Silicosis, Asbestosis, Coal Worker's Pneumoconiosis, Mixed Dust Fibrosis.	2
4.1.2	Occupational Asthma (i.e. Byssinosis) & Extrinsic Allergic Alveolitis (like Bagassosis).	1
4.1.3	Pulmonary Function Test. ILO Radiograph on Pneumoconiosis.	1
4.1.4	Notifiable Occupational Diseases in India as per Factories Act, 1948. ILO list of Occupational Diseases.	1

4.2	**Ergonomics & Work Physiology (4 Hours)**	
4.2.1	Introduction to Ergonomics, application of ergonomics in industry	2
4.2.2	Stress and performance, anthropometry and work physiology	1
4.2.3	Physical fitness test in industry, fatigue, VO2Max, workload.	1
5	**Industrial Hygiene (9 Hours)**	
5.1	Introduction, principles and practices. Chemical Stresses/Agents at workplace.	1
5.2	Assessment of airborne contaminants in the work environment – including various methods of air-sampling for area and personal monitoring.	1
5.3	Concept of thresh-hold limit values/permissible limits of exposure and recommended exposure limits in industry.	1
5.4	Concept of air-borne contaminants by substitution, isolation, enclosure, wet methods.	1
5.5	Industrial ventilation – dilution and local exhaust systems.	1
5.6	Material Safety Data Sheets (MSDS). Biological monitoring and its applications.	2
5.7	Selection, use, care and maintenance of Respiratory & Non-respiratory Personal Protective Equipment.	2

CHT 383	PETROLEUM REFINERY ENGINEERING	CATEGORY	L	T	P	CREDIT
		VAC	3	1	0	4

Preamble: This course introduces students to the concepts of petroleum refinery operations that are relevant and used for applications in chemical engineering. This course summarizes various petroleum refinery operations like prelimary, primary and secondary. It also explains the classification and evaluation of crude oil. It also outlines the treatments of petroleum products their properties, applications and test methods.

Prerequisite: Nil

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

CO 1	Apply the basic principles of chemical engineering in the storage, selection and evaluation of crude oil to optimize the refinery operation.
CO 2	Apply the basic principles of distillation in the atmospheric and vacuum distillation unit and analyze the preliminary refinery operation.
CO 3	Analyze thermal and catalytic conversion process as a part of the secondary conversion process.
CO 4	Judge the selection of various techniques to improve the quality of gasoline to meet the Bharath stage norms and treatment techniques to other petroleum products.
CO 5	Explain various test methods to the petroleum products to meet the specification and understand the properties and uses of petroleum products.

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
CO 3	3											3
CO 4	3					3	3					3
CO 5	3		2			2	3					3

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	20
Understand	10	10	30
Apply	20	20	40
Analyse	10	10	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): To apply the basic principles of chemical engineering in the storage, selection and evaluation of crude oil to optimize the refinery operation.

1. Write the classification of Petroleum refinery.
2. Give the significance of evaluation of oil stock.
3. Why TBP analysis is widely used for crude oil assay.

Course Outcome 2 (CO2): To apply the basic principles of distillation in the atmospheric and vacuum distillation unit and analyze the preliminary refinery operation.

1. How vacuum is generated in the VDU.
2. Why pre treatment is necessary for crude oil.
3. Discuss about the topping operation in the refinery.

Course Outcome 3(CO3): To analyze thermal and catalytic conversion process as a part of the secondary conversion process.

1. What are the advantages of thermal conversion process?
2. What are the advantages of Zeolite type catalyst used in the FCCU?
3. Name any five-technology supplier for catalytic cracking.

Course Outcome 4 (CO4): To judge the selection of various techniques to improve the quality of gasoline to meet the Bharath stage norms and treatment techniques to other petroleum products.

1. CCR is widely used in refinery. Why?
2. Discuss the significance of reforming process in the refinery.
3. Analyse the importance of isomerisation process in the refinery.

Course Outcome 5 (CO5): To explain various test methods to the petroleum products to meet the specification and understand the properties and uses of petroleum products.

1. Define cetane number. How the cetane number of diesel is determined.
2. Define smoke point. Discuss the features of smoke point apparatus.
3. Define viscosity index. Explain how the viscosity index is calculated.

Model Question paper

QP CODE: **PAGES:3**

Reg No:_____ **Name :_____**

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIFTH SEMESTER B. TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: CHT383

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

CHT 383 PETROLEUM REFINERY ENGINEERING

(2019-Scheme)

PART A

(Answer all questions, each question carries 3 marks)

1. Differentiate between TBP and ASTM distillation.
2. What do you mean by the complexity of the refinery?
3. What is the role of prefractionator?
4. What is the significance of Vacuum distillation unit?
5. Differentiate between thermal cracking and catalytic cracking.
6. FCCU is considered as gasoline engine of the refinery. Why.
7. What is the type and composition of catalyst used in reforming reaction?
8. Analyse the importance of isomerisation process in the refinery.
9. What are the properties and specification of superior kerosene?
10. Define Octane number and Cetane number. (10x3 = 30 marks)

PART B

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

MODULE I

11. a) Discuss the composition of Crude oil.
    b) Write the classification of storage tanks used in the refinery. Explain any one of them in detail. (7+7 = 14 marks)
12. a) Discuss about the evaluation of crude oil.
    b) What is GRM and how it is calculated. (9+5 = 14 marks)

MODULE II

13. With neat diagram explain the working of Electric desalter. What are the parameters affecting the performance of Electric desalter? (14 marks)

14. a) Write the classification of Furnaces used in the refinery.
    b) With neat diagram explain the working of ADU. (5+9 = 14 marks)

MODULE III

15. a) With neat diagram explain the working of Delayed coker.
    b) What are the advantages of Catalytic conversion process? (9+5 = 14 marks)

16. a) With neat diagram explain the working of Hydrocracker.
    b) What are the process parameters for hydro cracking? Explain. (9+5 = 14 marks)

MODULE IV

17. a) With a neat diagram explain the working of sulphuric acid alkylation process.
    b) Discuss the significance of hydro treatment in the refinery. (10+4 = 14 mark)

18. a) With neat diagram explain the working of CCR process.
    b) Draw a block diagram of hydrogen generation in refinery. (9+5 = 14 marks)

MODULE V

19. a) With neat diagram explain the Merox treatment of LPG.
    b) With neat diagram explain the dewaxing by chilling and pressing.
    (7+7 = 14 marks)

20. a) What are the properties, test methods and uses of Lubricating oil? Explain.
    b) What are the properties, test methods and uses of Bitumen? Explain.
    (7+7 =14 marks)

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Syllabus

Module 1 (8 hrs)

Storage and transportation of crude oil and products. Classification, Composition and Evaluation of oil stock. Status of Petroleum industry in India. Classification of petroleum refinery. Fundamentals of Refinery economics, Refinery complexity. Challenges of Indian refinery and its prospects.

Module 2 (9 hrs)

Preliminary petroleum processing-Impurities in crude oil, Dehydration and desalting of crude- Electric Desalter - Process description, factors affecting the electric desalter. Pipe still furnaces and its operations. Distillation of crude - Pre-fractionator, Atmospheric topping unit, Vacuum distillation unit.

Module 3 (10 hrs)

Thermal Conversion process. Thermal cracking, Visbreaking, Coking – Delayed coking. Types and uses of petroleum coke.

Catalytic conversion process- Catalytic Cracking - Types of Catalyst. Process description of Fluid Catalytic cracking unit. Process description and applications of Hydro cracking. Comparison of Thermal, Catalytic and Hydro cracking.

Module 4 (10 hrs)

Quality up gradation of gasoline- Catalytic Reforming - Catalyst-Process description. Catalyst, Process description and application of Alkylation - Sulphuric acid alkylation, Isomerisation with Platinum catalyst. Supporting process in Refinery - Hydrogen production, Acid gas removal and Sulphur recovery process- Modified Claus process.

Treatment of gasoline- Copper Chloride process and Merox sweetening. Production and treatment of L.P.G. Diesel Hydro desulphurisation (DHDS) and production of Ultra low sulphur Diesel (ULSD), Bharath stage norms of Diesel and Gasoline.

Module 5 (8 hrs)

Treatment of Kerosene - Edeleanu process. Production and treatment of Lube - Phenol extraction. Dewaxing methods- Chilling and pressing and MEK dewaxing.

Properties, test methods and uses of Refinery products such as L.P.G, Gasoline, Jet fuel, Kerosene, Diesel fuel, Lube oil and Bitumen.

Text books:

1. Bhaskara Rao B.K, Modern Petroleum Refinery Process, Oxford& IBM
2. Dr. Ram Prasad, Petroleum Refining Technology, Khanna Publishers
3.

References:

- Dr. Kochu Baby Manjooran S, Modern Petroleum Chemistry
- James H. Garry Glenn E. Handwerk Mark J. Kaiser, Petroleum Refinery Technology and Economics, CRC Press, Taylor and Francis group.

- I D Mall, Petrochemical Process technology, Macmillan
- Nelson W.L, Petroleum Refinery Engineering, McGraw Hill
- Gopala Rao M & Sitting M, Dryden's Outline of Chemical Technology, Affiliated East West Press

Course Contents and Lecture Schedule

No.	Topic	No. of Lectures
1	**Module I (8 hrs)**	
1.1	Storage and transportation of crude oil and products	2hrs
1.2	Classification, Composition and Evaluation of oil stock	3hrs
1.3	Status of Petroleum industry in India and Classification of petroleum refinery	1hr
1.4	Fundamentals of Refinery economics	1hr
1.5	Challenges of Indian refinery and its prospects.	1hr
2	**Module II (Preliminary and Primary refinery operations) (9 hrs)**	
2.1	Impurities in crude oil, Dehydration and desalting of crude	1hr
2.2	Electric Desalter- Types, Process, factors affecting electric desalter	1hr
2.3	Furnaces and its operations	2hrs
2.4	Distillation of crude - Pre-fractionator, Atmospheric topping unit.	3hrs
2.5	Vacuum distillation unit	2hr
3	**Module III (Cracking and Coking Operations) (10 hrs)**	
3.1	Thermal cracking and its application	1hr
3.2	Visbreaking	1hr
3.3	Coking – Delayed coking	1hr
3.4	Types, properties and uses of petroleum coke	1hr
3.5	Catalytic cracking-Types of Catalyst	1hr
3.6	Fluid catalytic Cracking unit	2 hrs
3.7	Process description and applications of Hydro cracking	2 hr
3.8	Comparison of Thermal, Catalytic and Hydro cracking	1 hr
4	**Module IV (10 hrs)**	
4.1	Catalytic reforming- Catalyst-Process description	1hr
4.2	Catalyst, Process variables, Process description and application of Alkylation, Isomerisation	3hrs
4.3	Supporting process in Refinery- Hydrogen production, Acid gas removal and Sulphur recovery process- Modified Claus process.	2hrs
4.4	Treatment of gasoline- Copper Chloride process and Merox sweetening.	2hrs
4.5	Production and treatment of LPG	1hr
4.6	Diesel Hydro desulphurisation (DHDS) and production of Ultra low sulphur Diesel (ULSD), Bharath stage norms of Diesel and Gasoline	1 hr
5	**Module V (8 hrs)**	

5.1	Treatment of Kerosene- Edeleanu process. Production and treatment of Lube- Phenol extraction	3hrs
5.2	Dewaxing methods- Chilling and pressing and MEK dewaxing.	1 hr
5.3	Properties, test methods and uses of Refinery products such as L.P.G, Gasoline, Jet fuel, Kerosene, Diesel fuel, Lubricating oil, and Bitumen.	4 hrs

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
KTU
Estd.
2014

CHT385	POLYMER TECHNOLOGY	CATEGORY	L	T	P	CREDIT
		VAC	3	1	0	4

Preamble: This course imparts basic knowledge on polymers, which includes classification, theory and processing of high polymers. This also incorporates the study on the properties and applications of different polymers, testing of mechanical and physical properties which will enable the students in selecting suitable polymers for engineering applications. This course will provide immense scope for research in the area of material development.

Prerequisite: Basic concepts of Material Science

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

CO 1	Classify types and mechanisms of polymerization
CO 2	Summarize the classes, properties and engineering uses/applications of different polymeric materials
CO 3	Describe the concepts behind different types of molecular weights and methods for their determination.
CO 4	Analyse the rheology and mechanical properties of polymers
CO 5	Explain the processing methods and moulding techniques
CO 6	Describe the elastomer processing methods and vulcanization of rubber.

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	3										
CO 4	3	3										
CO 5	3					3						2
CO 6	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. List the types of polymerisation giving suitable examples.
2. Outline the method of emulsion polymerisation.
3. Illustrate the kinetics of vinyl polymerisation.

Course Outcome 2 (CO2)

1. Evaluate the properties of phenol formaldehyde and outline its applications.
2. Classify polymers based on their structure.
3. Discuss the factors affecting polymer properties.

Course Outcome 3(CO3):

1. State and explain weight average and number average molecular weights.
2. Describe the viscosity average molecular weight determination.
3. Illustrate the end group analysis.

Course Outcome 4 (CO4):

1. Demonstrate the viscoelastic properties of polymers with a suitable model.
2. Define apparent viscosity. How is it measured?
3. Describe a method to determine melt flow index.

Course Outcome 5 (CO5):

1. Classify the additives used in polymer processing giving examples in each category.
2. Illustrate the injection moulding technique with a diagram.
3. Demonstrate wet, dry and melt spinning methods with proper diagrams.

Course Outcome 6 (CO6):

1. Describe the process of vulcanisation of rubber.
2. Discuss the compounding methods for elastomers.
3. Outline the characteristic features of nanocomposites.

Model Question paper

QP CODE: **Reg No:**_____

PAGES:3 **Name :**_____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIFTH SEMESTER B. TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: CHT 385

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

CHT 385 POLYMER TECHNOLOGY

(2019-Scheme)

PART A

(Answer all questions, each question carries 3 marks)

1. State and explain functionality with examples.

2. Distinguish between addition and condensation polymerisation

3. Give three terms of expressing compositions of a gas mixture.

4. Illustrate the types of copolymers with examples.

5. What is glass transition temperature? List the factors affecting T_g.

6. Discuss the oxidative degradation of polymers.

7. With a neat diagram, classify fluids based on rheology.

8. Discuss the role of plasticizers and heat stabilizers in polymer processing.

9. What is meant by vulcanization of rubber?

10. Define nanocomposites. Mention their advantages and disadvantages. **(10x3=30)**

PART B

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

Module –1

11. a) Discuss the classification of polymers based on source, structure and thermal response giving suitable examples.
    b) Distinguish between cationic and anionic polymerisations.

12. a) Outline the steps involved in free radical polymerisation with a suitable example.
    b) Derive the kinetics of condensation polymerisation.

Module –2

13. a) List the types of averaging of molecular weights of polymers and define them.
    b) Sketch the molecular weight distribution curve and explain its significance.
14. State and explain the principle of light scattering method. With proper diagrams describe the determination of molecular weight by this method.

Module –3

15. a) What are nylons? Describe the properties and applications of nylons.
    b) Give the structure of polycarbonates. Describe preparation of polycarbonate and mention the properties.
16. a) Define bioplastics. Discuss the preparation, properties and applications of poly lactic acid.
    b) Write a note on butyl rubber.

Module –4

17. a) Define melt flow index. Illustrate a method for its determination.
    b) Demonstrate stress relaxation and creep with a suitable model.
18. a) What is rubber like elasticity? Explain.
    b) Discuss the functions of ultraviolet absorbers and flame retardants.

Module –5

19. a) With a neat diagram, describe the injection moulding technique.
    b) Explain the terms mastication and. mixing in the processing of elastomers.

20. a) Discuss the various spinning methods for fibres with proper sketches.
    b) What is a nanocomposite? Discuss the types of nanocomposites and their applications.

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Syllabus

Module 1 (9 Hrs)

Introduction to polymers-monomer, functionality, classification of polymer based on source, structure, application, thermal behaviour, mode of polymerization. Kinetics of polymerisation – addition polymerization and condensation polymerisation – free radical polymerization – anionic and cationic polymerization. Copolymerisation-Different types of copolymers – Characteristic features. Methods of polymerization – bulk, solution, suspension and emulsion polymerization.

Module 2 (9 Hrs)

Molecular weight of polymers – weight average and number average molecular weight – sedimentation and viscosity average molecular weights. Experimental methods for molecular weight determination – end group analysis, light scattering method – viscometry (Ostwald viscometer) intrinsic viscosity. Molecular weight distribution curve. Factors affecting polymer properties – crystallinity – orientation treatment – solubility of polymers – glass transition temperature – types of polymer degradation – effect of reinforcement on the properties.

Module 3 (9 Hrs)

Manufacture, properties and applications of polymers- Thermoplastics – ABS – acrylics – cellulose acetate – fluoropolymers (PTFE) – nylons – polycarbonate – PVC – PE– PP – PS – polyurethanes. Thermosetting plastics – epoxy – phenol formaldehyde – urea formaldehyde – polyesters – silicones. Bioplastics – Poly lactic acid (PLA). Elastomers- Butyl rubber -Nitrile rubber.

Module 4 (9 Hrs)

Properties of polymers – rheology- viscous flow – apparent viscosity – rubber like elasticity – stress strain behaviour of elastomers – viscoelasticity – stress relaxation and creep – measurement of rheological properties – melt flow index (MFI) – capillary rheometers. Estimation of tensile strength of polymers. Addictives for polymer processing - effect of additives used – plasticizers – colourants – heat stabilizers - antioxidants – ultraviolet absorbers – antistatic agents – flame retardants – blowing agents – lubricants and fillers.

Module 5 (9 Hrs)

Plastic processing – injection moulding – compression moulding – calendaring – blow moulding – extrusion – thermoforming – wet, dry and melt spinning methods for fibres – vulcanization of rubber — general study of elastomer processing - brief description of compounding methods. Introduction to nano composites-types and applications.

Text Books:

1. Billmeyer F.W., Text book of polymer science, John Wiley.
2. Gowariker V.R. Polymer Science, New Age.

Reference Books:

1. Premamoy Ghosh., Polymer Science and Technology, Tata Mc Graw Hill.
2. Rodrigues F., Principles of polymer systems, Tata Mc Graw Hill
3. Shah V.H., Handbook of plastic testing technology, Wiley, 1998

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Introduction to Polymers, Classification and kinetics (9 Hrs.)**	
1.1	Monomer, functionality	1
1.2	Classification of polymer based on source, structure, application, thermal behaviour, mode of polymerization	1
1.3	Kinetics of polymerization- addition polymerization- free radical polymerization- anionic and cationic polymerization	2
1.4	Kinetics of step growth polymerisation	1
1.5	Different types of copolymers- Characteristic features, Copolymer equation.	2
1.6	Methods of polymerization – bulk, solution, suspension and emulsion polymerization	2
2	**Molecular weight of polymers (9 Hrs.)**	
2.1	Weight average and number average molecular weight	1
2.2	Sedimentation and viscosity average molecular weight	1
2.3	Experimental methods of molecular weight determination- end group analysis.	1
2.4	Light scattering method - viscometry	2
2.5	Molecular weight distribution curve	1
2.6	Factors affecting polymer properties	1
2.7	Types of polymer degradation	2
3	**Manufacture, properties and applications Bioplastics, Elastomers (9 Hrs.)**	
3.1	Thermoplastics-ABS – acrylics – cellulose acetate – fluoropolymers (PTFE) – nylons.	2
3.2	Polycarbonate – PVC – PE– PP – PS – polyurethanes.	2
3.3	Thermosetting plastics – epoxy – phenol formaldehyde – urea formaldehyde– polyesters – silicones.	2
3.4	Bioplastics- Poly lactic acid.	1
3.5	Elastomers-Natural rubber- Butyl rubber- Nitrile rubber.	2
4	**Rheology and Testing of polymers and additives used (9 Hrs.)**	

4.1	Properties of polymers – rheology- viscous flow -stress strain behaviour of elastomers – viscoelasticity – stress relaxation and creep	3
4.2	Measurement of rheological properties – melt flow index (MFI) – capillary rheometers.	2
4.3	Testing of tensile strength of polymers.	1
4.4	Effect of additives used; plasticizers; colourants	1
4.5	Heat stabilizers; antioxidants; ultraviolet absorbers	1
4.6	Antistatic agents; flame retardants; blowing agents, Lubricants and fillers.	1
5	**Processing of plastics and elastomers (9 Hrs.)**	
5.1	Injection moulding – compression moulding	2
5.2	Calendaring – blow moulding- Extrusion – thermoforming –	2
5.3	wet, dry and melt spinning methods for fibres	1
5.4	Vulcanization of rubber -General study of elastomer processing methods.	2
5.5	Introduction to nano composites	2

***

SEMESTER V

HONOURS

CHT 393	ADVANCED HEAT TRANSFER	CATEGORY	L	T	P	CREDIT
		VAC	3	1	0	4

Preamble:
The advanced course in heat transfer is the next higher level of the theory course *CHT 204 Heat Transfer Operations*. The course covers topics such as one-dimensional steady state conduction, multidimensional conduction, unsteady state conduction, heat transfer through extended surfaces and also deals with convective and radiative heat transport analysis.

Prerequisite: Basic knowledge in heat transfer operations.

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

CO 1	Apply the concepts of conduction heat transfer to the design of heat-transfer equipment and solve related engineering problems.
CO 2	Explain the concept and applications of heat transfer through extended surfaces.
CO 3	Elaborate the phenomenon of unsteady state conduction of various types.
CO 4	Apply the concepts of convection heat transfer to solve complex heat transfer problems.
CO 5	Apply the concepts of radiation heat transfer to solve complex heat transfer 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	PO 10	PO 11	PO 12
CO 1	3	2	2									
CO 2	3											
CO 3	3											
CO 4	3	2	2									
CO 5	3	2	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): Apply the concepts of conduction heat transfer to the design of heat-transfer equipment and solve related engineering problems.

1. Write short note on thermal conductivity of materials.
2. Write down the general heat conduction equation.
3. Derive the general three-dimensional heat conduction equation in spherical co-ordinate system.

Course Outcome 2 (CO2): Explain the concept and applications of heat transfer through extended surfaces.

1. Differentiate between fin efficiency and effectiveness.
2. Sketch three different types of fins.
3. Derive the expression for temperature distribution and heat flux for a rectangular fin.

Course Outcome 3 (CO3): Elaborate the phenomenon of unsteady state conduction of various types.

1. Define a semi-infinite solid.
2. What are Heisler charts?
3. Derive the expression for temperature distribution of a solid undergoing transient conduction. Assume negligible internal resistance.

Course Outcome 4 (CO4): Apply the concepts of convection heat transfer to the design of heat-transfer equipment and solve related engineering problems.

1. List out the factors that influence the convective heat transfer coefficient.
2. Explain thermal boundary layer.
3. Derive x-momentum equation.

Course Outcome 5 (CO5): Apply the concepts of radiation heat transfer to design of heat-transfer equipment and solve related engineering problems.

1. Write short note on thermal radiation.
2. State and explain Planck's law.
3. A gray surface is maintained at a temperature of 827 ^{0} C. If the maximum spectral emissive power at that temperature is 1.37 x 10^{10} W/m^3, determine the emissivity of the body and the wavelength corresponding to the maximum spectral intensity of radiation.

Model Question Paper

QP CODE: **PAGES:2**

Reg No:_____ **Name :_____**

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIFTH SEMESTER B. TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: CHT 393

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

ADVANCED HEAT TRANSFER

(2019-Scheme)

PART A

(Answer all questions, each question carries 3 marks)

1. Write short note on thermal conductivity of materials.
2. Write down the general heat conduction equation.
3. Differentiate between fin efficiency and effectiveness
4. Sketch three different types of fins.
5. Define a semi-infinite solid.
6. What are Heisler charts?
7. List out the factors that influence the convective heat transfer coefficient.
8. Explain thermal boundary layer.
9. Write short note on thermal radiation.
10. State and explain Planck's law.

PART B

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

Module -I

11. Derive the general three- dimensional heat conduction equation in spherical co-ordinate system.
12. A thick-walled tube of stainless steel having a k = 21.63 W/mK with dimensions of 0.0254 ID and 0.0508 OD is covered with a 0.0254 m thick layer of insulation (k = 0.2423 W/mK). The inside wall temperature of the pipe is 811 K and the outside surface of insulation is at 310.8 K. For a 0.305 m length of pipe, calculate the heat loss and also the temperature at the interface between the metal and the insulation.

Module -II

13. Derive the expression for temperature distribution and heat flux for a rectangular fin.
14. One end of a very long aluminium rod is connected to a wall at 140 ^{0} C, while the other end protrudes into a room whose air temperature is 15 ^{0} C. The rod is 3 mm in diameter and the heat transfer coefficient between the rod and the environment is 300 W/m^{2}K. Estimate the total heat dissipated by the rod taking its thermal conductivity as 150 W/mK.

Module -III

15. Derive the expression for temperature distribution of a solid undergoing transient conduction. Assume negligible internal resistance.
16. Explain chart solutions for unsteady state heat transfer.

Module -IV

17. Derive x-momentum equation.
18. Describe the development of hydrodynamic and thermal boundary layers.

Module -V

19. State and explain laws of radiation.
20. A gray surface is maintained at a temperature of 827 ^{0} C. If the maximum spectral emissive power at that temperature is 1.37 x 10^{10} W/m^3, determine the emissivity of the body and the wavelength corresponding to the maximum spectral intensity of radiation

(14x 5 =70)

Syllabus

Module 1 (Conduction heat transfer)

Review of conduction convection and thermal radiation fundamentals. Thermal conductivity. Temperature and pressure dependence of thermal conductivity. Thermal conductivity of solids, liquids and gases. Combined mechanisms of heat transfer. The general differential equation for energy transfer. Steady state one-dimensional conduction with and without heat generation.

Module 2 (Heat transfer from extended surfaces)

Heat transfer from extended surfaces. Rectangular plate fin of uniform cross section: Long fins, Fin with insulated end, Fins with convection off the end. Pin fin (spine) of uniform cross section. Efficiency and effectiveness of fins. Error estimation in temperature measurement. Multi-dimensional heat conduction - Conduction in two dimensional systems: Analytical solution to a thin, infinitely long rectangular plate without any heat source.

Module 3 (Unsteady state conduction)

Unsteady state conduction. Lumped parameter analysis; Systems with negligible internal resistance. Response time of a temperature measuring instrument. Systems with negligible surface resistance. Heat flow in an infinitely thick plate (Semi-infinite body). Systems with finite surface and internal resistance. Chart solutions of transient heat conduction problems.

Module 4 (Convection heat transfer)

Convection heat transfer. The convective heat transfer coefficient. The basic equations: continuity equation, the momentum equation and the energy equation. Heat transfer in laminar and turbulent flows. The boundary layer theory. Hydrodynamic and thermal boundary layers. Exact analysis of the laminar boundary layer. Approximate analysis of the thermal boundary layer.

Module 5 (Radiation heat transfer)

Radiation heat transfer: Nature of radiation. Thermal radiation. The intensity of radiation. Laws of radiation. Emissivity and absorptivity of solid surfaces. Radiant heat transfer between black bodies. Radiant heat transfer between gray surfaces. Radiation from gases. The radiation heat transfer coefficient.

Text Books

1. Welty J.R et al., *Fundamentals of Momentum, Heat and Mass Transfer*, John Wiley & Sons
2. Hollman J.P., *Heat Transfer*, McGraw Hill
3. Dutta B.K., *Heat Transfer: Principles and Applications*, Prentice Hall India

Reference Books

1. Bird et al., *Transport Phenomena*, John Wiley & Sons.
2. Foust A.S et al., *Principles of Unit Operations*, John Wiley & Sons.
3. McCabe W.L., Smith J.C. &Harriott P., *Unit Operations in Chemical Engineering*, McGraw Hill
4. Coulson J.M. & Richardson J.F., *Chemical Engineering*, Vol. I and II, ELBS, Pergamon Press
5. Geankopolis C J, *Transport Processes andSseparation Process Principles*, Prentice Hall of India, 4th Edition, Eastern Economy Edition (2004)
6. Incropera F P and DeWitt D P, *Introduction to Heat Transfer*, 2nd Ed John Wiley New York (1996).
7. M.Necati. Ozizik, *Heat transfer - A Basic Approach*, McGraw-Hill College (1985)
8. Kern D.Q., *Process Heat Transfer*, McGraw Hill

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Conduction heat transfer (9 hours)**	
1.1	Review of conduction convection and thermal radiation fundamentals.	3
1.2	Thermal conductivity. Temperature and pressure dependence of thermal conductivity. Thermal conductivity of solids, liquids and gases.	1
1.3	Combined mechanisms of heat transfer.	1
1.4	The general differential equation for energy transfer.	1

1.5	Steady state one-dimensional conduction with and without heat generation.	3
2	**Heat transfer from extended surfaces (9 hours)**	
2.1	Heat transfer from extended surfaces. Rectangular plate fin of uniform cross section: Long fins, Fin with insulated end, Fins with convection off the end.	3
2.2	Pin fin (spine) of uniform cross section.	1
2.3	Efficiency and effectiveness of fins.	1
2.4	Error estimation in temperature measurement.	1
2.5	Multi-dimensional heat conduction: Two- and three-dimensional systems (introduction only). Numerical solutions.	3
3	**Unsteady state conduction (9 hours)**	
3.1	Unsteady state conduction. Lumped parameter analysis; Systems with negligible internal resistance.	2
3.2	Response time of a temperature measuring instrument.	1
3.3	Systems with negligible surface resistance.	2
3.4	Heat flow in an infinitely thick plate (Semi-infinite body). Systems with finite surface and internal resistance.	3
3.5	Chart solutions of transient heat conduction problems.	1
4	**Convection heat transfer (9 hours)**	
4.1	Convection heat transfer. The convective heat transfer coefficient.	1
4.2	The basic equations: Continuity equation, the momentum equation and the energy equation.	2
4.3	Heat transfer in laminar and turbulent flows.	1
4.4	The boundary layer theory. Hydrodynamic and thermal boundary layers.	2
4.5	Exact analysis of the laminar boundary layer. Approximate analysis of the thermal boundary layer.	3
5	**Radiation heat transfer (9 hours)**	
5.1	Radiation heat transfer: Nature of radiation. Thermal radiation. The intensity of radiation.	2
5.2	Laws of radiation. Emissivity and absorptivity of solid surfaces.	2
5.3	Radiant heat transfer between black bodies. Radiant heat transfer between gray surfaces.	3
5.4	Radiation from gases. The radiation heat transfer coefficient.	2

CHT 395	PHYSICO CHEMICAL METHODS IN ENVIRONMENTAL ENGINEERING	CATEGORY	L	T	P	CREDIT
		VAC	3	1	0	4

Preamble:
This course presents the physical and chemical principles for the treatment of dissolved and particulate contaminants in water and wastewater. These concepts will provide an understanding of the design of commonly used unit operations in water and wastewater treatment systems. Applications will be discussed as well. Topics covered include water characteristics, reactor dynamics, filtration, coagulation/flocculation, sedimentation, adsorption, gas stripping, disinfection, and chemical oxidation.

Prerequisite: CHT303 Environmental Engineering

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

CO 1	Select suitable equipment for the physicochemical treatment of water and wastewater
CO 2	Design physicochemical processes for water and wastewater treatment
CO 3	Estimate the quantity of water/ wastewater and fluctuations of flow from various sources
CO 4	Design screens, grit chamber, equalization and floatation tank
CO 5	Explain the principles of adsorption and disinfection in wastewater treatment
CO 6	Explain the principles of ion-exchange and membrane process in wastewater treatment

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	2			3					
CO 2	3	3	3	2			3					
CO 3	3			2			3					
CO 4	3	3	3	2			3					
CO 5	3	3	3	2			3					
CO 6	3	3	3	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 (CO1):

1. Explain different types of settling.
2. Explain the merits and demerits of coagulation process in sewage treatment.
3. Explain different types of sedimentation tanks.
4. Explain in detail about the mechanism of filtration and different type filtration media.
5. Design a Rapid Sand Filter unit for 4 million litres per day (MLD) of supply with all its principal components.

Course Outcome 2 (CO2):

1. Explain the role of equalization tanks in wastewater treatment. Distinguish between two flow arrangements with flow diagram.
2. A settling column analysis is run on a type-I suspension. The settling column is 2 m tall and the initial concentration of the well-mixed sample is 650 mg/L. Results of the analysis are below:

Time, min.	0	58	77	91	114	154	250
conc. remaining, mg/L	650	560	415	325	215	130	52

What is the theoretical efficiency of the settling basin that receives this suspension if the loading rate is 2.4×10^{-2} m/min? Which parameters need to be varied to increase removal efficiency?

Course Outcome 3 (CO3):

1. The collection system in a town was studied for its dry-weather and wet-weather flow characteristics. The study, which lasted for three months. Showed the average peak dry weather flow to be 205 L/s, the average minimum dry-weather flow to be 46 L/s, and the average flow to be 96 L/s. The combined infiltration -inflow was found to be 70 L/s. The sewage inflow records were also analysed for the average flow of the driest months of each year (average of the flow during the successive months of June, July and August of each year of record) yielding the following probability distribution.

Average dry-weather flow (L/capita-day)	Probability p that flow is equaled or exceeded)

310	0.019
307	0.080
304	0.23
300	0.38
.	.
.	.
.	.
160	0.84
147	0.99

(a) Find the ratios of the minimum and the maximum flows to the average flow. (b) If the midyear population of the town is 58,600, what are the present minimum, maximum and average flows of the town assuming 10 % probability of occurrence as the criterion for determining flows?

2. Explain different types of population forecasting methods with equation.

Course Outcome 4 (CO4):

1. A horizontal grit chamber of length16m and width 1m is used for grit removal for a particle diameter of 0.3 mm and density 1400 kg/m^3. The wastewater approach velocity carrying the grit particle is 0.3 m/s and the flow rate is 0.15 m^3/s. Check whether the particle will be settled in the grit chamber or not. (Density of wastewater = 1000kg/m^3, viscosity = 0.001 kg/m.s).
2. Determine the % increase in the head loss through the bar screen when 50 % of flow area is blocked off due to the accumulation of coarse solids.

Assume the following conditions:

Approach velocity = 0.6 m/s

Velocity through clean bar screen = 0.9 m/s

Open area for flow through clean bar screen = 0.19 m^2

Head loss coefficient for clean bar screen = 0.7

3. 50 mg/L of alum is added to 50,000 m^3/day of raw water containing 60 mg/L of suspended solids. (a) Assuming that sufficient natural alkalinity is present, estimate the quantity of sludge is produced in kg/day (b) Assuming that the specific gravity of the sludge is 1.04, calculate the sludge produced in m^3/day. Assume that the removal efficiency of the settling basin is 65 %.

Course Outcome 5 (CO5):

1. Derive Langmuir adsorption isotherm with all the assumptions.
2. Explain different methods of effluent disinfection process.
3. Explain the chemistry of chlorination.
4. Explain the following (i) Free chlorine (ii) available chlorine (iii) total residual chloring
5. Explain with the graph, Breakpoint chlorination.

Course Outcome 6 (CO6):

1. Explain the general reaction mechanism of cation and anion exchange resins.
2. Define (i) Selectivity (ii) exchange capacity
3. Explain *electrodialysis membrane* and *pressure membrane* processes.
4. Explain membrane performance characteristics.

5. Explain different types of membranes with examples.

Model Question paper

Name : **Reg. No**

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
FIFTH SEMESTER B. TECH DEGREE EXAMINATION, Month& Year
CHEMICAL ENGINEERING
CHT 395 PHYSICO CHEMICAL METHODS IN ENVIRONMENTAL ENGINEERING
(2019 Scheme)

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

PART A

(Answer all questions. Each question carries 3 marks)

1. List the sources of drinking water.
2. Explain the term coagulation and flocculation.
3. State the physical and chemical characteristics of waste water
4. Briefly explain the effluent standards and their salient features
5. Explain any two methods for the removal of suspended solids.
6. What are the different types of screens used in waste water treatment plant?
7. What are the two types of hardness, the ions causing them and methods to remove them from drinking water?
8. What are the different methods of disinfection?
9. Explain the theory of filtration.
10. Write the fundamentals of adsorption

PART B

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

Module 1

11. a) What is the difference between rapid and slow sand granular filtration design criteria?
    b) Explain the Hydraulics of Flow through Granular Media filter

12. The average flowrate at small municipal waste water treatment plant is 20, 000m3/day. The highest observed peak daily flowrate is 50000m3/day. Design rectangular primary clarifiers with a channel width of 6m(20ft). Use a minimum of two clarifiers. Calculate the scour velocity to determine if settled material will become resuspended. estimate the BOD and TSS removal at average and peak flow. Use an overflow rate of 40m3/m2 -d average flow rate and a slide water depth of 4m (13.1 ft).

Module II

13. Evaluate the significance of physical and chemical treatment in waste water
14. Discuss various advanced methods in treatment of water

Module III

15. Explain the types of aerators with suitable figures. Discuss the purpose and methods of aeration in water treatment.
16. a**)** What is the design information for aerated flow grit chambers?
    b) Design an aerated grit chamber for the treatment of municipal waste water. The average flow rate is 0.1 m^3/s and the peaking factor is 2.75. Determine peak flowrate, grit chamber volume, width to depth ratio (1.2:1), detention time, total air supply requirement, volume grit. assume that the depth, and flowrate are 3m and $0.3m^3$/min-m respectively

Module IV

17. Give an account on Ion Exchange Process. Explain its advantages also.
18. Explain various types of chlorination in water treatment? Define break point chlorination and double chlorination

Module V

19. Discuss the working principle, flux equation and applications of ultrafiltration process with neat sketch.
20. a) With suitable sketch explain the basic principle of membrane separation process.
    b) What is membrane fouling? State the sources of fouling and remedies (14*5=70)

Syllabus

Module I (10 Hrs.)

Physicochemical Water treatment: Sources of water, physical and chemical quality of water, water quality standards-Significance of physicochemical treatment –Principle and objectives of Physical & chemical treatment units sedimentation processes-types of settlings - tube settlers - design of sedimentation tanks, coagulation and flocculation-coagulation processes; filtration-filtration processes-filter media - types of filters, hydraulics of filtration-filter problems-design of filters

Module II (8 Hrs.)

Physicochemical Wastewater treatment: Wastewater sources, Physical and chemical characteristics of wastewater- Estimation and quantity of wastewater-Flow rate and fluctuations - Effluent standards - variations in concentrations of wastewater constituents-Analysis of mass loadings- treatment sequence-Preliminary, Primary, Secondary, Tertiary, advanced treatment.

Module III (9 Hrs.)

Theory and design of physicochemical unit operations for wastewater: Screening, grit removal Equalization - types of equalization process – volume of equalization basins - Floatation and aerosol separation - methods of floatation-gas particle contact - dissolved air floatation-decarbonation and Softening

Module IV (9 Hrs.)

Adsorption: - adsorption isotherms - adsorption kinetics - factors influencing - design of adsorption units

Disinfection processes: - methods of disinfection - factors influencing - non-chemical methods - details of chlorination - other disinfection processes

Module V (9 Hrs.)

Ion exchange: - process-materials-exchange reactions application in water and wastewater treatment-design of units

Membrane process: - Water softening – Demineralisation - Reverse osmosis - electro-dialysis - ultra filtration - membrane properties and types - process design

Text Books

1. Weber W.J Physicochemical processes for water quality control, John Willy and Sons, New York, 1990
2. Metcalf and Eddy Inc., Wastewater Engineering Treatment Disposal Reuse, Tata McGraw Hill Publishing Company, 2003.
3. Ronald L. Droste, Theory and practice of water and wastewater treatment, John Willy and sons (ASIA) Pvt Ltd, 1997.
4. Mark J Hammer, Mark J Hammer Jr, Water and wastewater technology Prentice Hall of India Pvt Ltd, 2007.
5. Santhosh Kumar Garg, Water supply engineering, Khanna publishers, 1996.
6. Santhosh Kumar Garg, Sewage disposal and air pollution engineering, Khanna publishers, 2008.

Reference Books

1. Nicholas P Cheremisinoff, HANDBOOK OF WATER AND WASTEWATER TREATMENT TECHNOLOGIES, Butterworth-Heinemann Publishers, USA, 2002
2. Arceivala, S.J., Wastewater Treatment for Pollution Control, TMH, New Delhi, Second Edition, 2000.
3. Manual on Sewerage and Sewage Treatment, CPHEEO, Ministry of Urban Development, Govt. of India, New Delhi, 1999.
4. Qasim, S.R. Wastewater Treatment Plant, Planning, Design & Operation, Technomic Publications, New York, 1994.
5. Lawrence K. Wang, Yung-Tse Hung, Nazih K. Shammas, Physicochemical Treatment Processes (HANDBOOK OF ENVIRONMENTAL ENGINEERING-Volume 3), Humana Press Inc. New Jersey 2005

Course Contents and Lecture Schedule

No	Topic	No. of Lectures (Hrs.)
1	**Physicochemical Water treatment: (10 Hrs.)**	
1.1	Sources of water, physical and chemical quality of water, water quality standards	2
1.2	Significance of physicochemical treatment–Principle and objectives of Physical & chemical treatment units	2
1.3	Sedimentation processes -types of settlings - tube settlers - design of sedimentation tanks	2
1.4	Coagulation and flocculation-coagulation processes	1
1.5	Filtration-filtration processes-filter media - types of filters, hydraulics of	2

	filtration	
1.6	Filter problems-design of filters	1
2	**Physicochemical Wastewater treatment: (8 Hrs.)**	
2.1	Wastewater sources, Physical and chemical characteristics of wastewater	1
2.2	Estimation and quantity of wastewater-Flow rate and fluctuations	2
2.3	Effluent standards - variations in concentrations of wastewater constituents	2
2.4	Analysis of mass loadings	1
2.5	Treatment sequence-Preliminary, Primary, Secondary, Tertiary, advanced treatment	2
3	**Theory and design of physicochemical unit operations for wastewater (9 Hrs.)**	
3.1	Screening	1
3.2	Grit removal	2
3.3	Equalization - types of equalization process – volume of equalization basins	2
3.4	Floatation and aerosol separation	1
3.5	Methods of floatation-gas particle contact	1
3.6	Dissolved air floatation	1
3.7	Recarbonation and Softening	1
4	**Adsorption and Disinfection processes**: **(9 Hrs.)**	
4.1	Adsorption isotherms	2
4.2	Adsorption kinetics - factors influencing	1
4.3	Design of adsorption units	2
4.4	Methods of disinfection	1
4.5	Factors influencing - non-chemical methods	1
4.6	Details of chlorination	1
4.7	Other disinfection processes	1
5	**Ion exchange and Membrane process: (9 Hrs.)**	
5.1	Ion exchange process-materials	1
5.2	Ion exchange reactions application in water and wastewater treatment	1
5.3	Design of Ion exchange units	1
5.4	Water softening – Demineralisation	1
5.5	Reverse osmosis - electro-dialysis	2
5.6	Ultra-filtration - membrane properties and types	2
5.7	Process design	1

CHT397	SOFT COMPUTING TECHNIQUES	CATEGORY	L	T	P	CREDIT
		VAC	3	1	0	4

Preamble: This course gives an introduction to some new fields in soft computing with its principal components of fuzzy logic, NN, GA and Fuzzy genetic hybrid systems.

Pre-requisite: Nil

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

CO 1	Explain the concepts involved in fuzzy logic systems.
CO 2	Design fuzzy logic controllers for various applications
CO 3	Train neural networks for various applications
CO 4	Solve optimisation problems using Genetic Algorithms
CO 5	Understand the concepts of Hybrid Soft computing 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	3	3		3	3							3
CO 2	3	3		3	3							3
CO 3	3	3		3	3							3
CO 4	3	3		3	3							3
CO 5	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. Explain the features of fuzzy membership functions with proper diagrams.
2. Discuss fuzzy equivalence relations and list out its properties?
3. For the fuzzy sets A = $\{0.2/x_1 + 0.9/x_2\}$ and B = $\{0.3/y_1 + 0.5/ y_2 + 1/y_3\}$, find the fuzzy relation A×B

Course Outcome 2 (CO2)

1. Defuzzify the following output membership function using centroid method:
   0/0, 0.3/1, 0.3/3.5, 0.5/4, 0.5/5.5, 1/6, 1/7, 0/8.
2. Explain any five defuzzification methods.

Course Outcome 3(CO3):

1. List the stage involved in Back Propagation Algorithm?

Course Outcome 4 (CO4):

1. Explain different types of Encoding Techniques.

Course Outcome 5 (CO5):

1. Explain the characteristics and different classifications of a neuro-fuzzy hybrid system.

Model Question paper

Name :Reg.No.

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
FIFTH SEMESTER B. TECH DEGREE EXAMINATION,
Month& Year
CHEMICAL ENGINEERING
CHT 397 Soft Computing Techniques
(2019 Scheme)

Duration: 3hours Max. Marks: 60

PART A

(Answer **all** questions. **Each** question carries 3 marks)

1. Distinguish between fuzzy and probability with example.
2. State the relevance of fuzzification. Explain different types.
3. What is unsupervised learning in ANN? Explain
4. Explain any training algorithm that can be used for training a multilayer feed forward neural network.
5. Explain radial basis function network.
6. State the significance of error portion δkand δjin Back Propagation Network.
7. What is the concept of crossover in Genetic Algorithm?
8. Write short note on application of GA.
9. Explain Genetic Neuro - Hybrid systems
10. Discuss the classification of Neuro Fuzzy Hybrid System?

PART B

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

Module 1

11. a) If membership functions A is {1/2 +0.5/3 + 0.6/4 + 0.2/5 + 0.6/6} and B is {0.5/2 + 0.8/3+0.4/4+0.7/5 + 0.3/6} find A/B and B/A (4 marks)

b) Two triangular membership functions are given as A = triang(1,3,4) and B=triang(3,5,6). Draw membership functions of $A \cap B$, $A \cup B$ and A'. (5 marks)

c) For the fuzzy sets A = $\{0.2/x_1 + 0.9/x_2\}$ and B = $\{0.3/y_1 + 0.5/ y_2 + 1/y_3\}$, find the fuzzy relation A×B (5 marks)

12. a) Using the intuition method develop fuzzy membership functions for the following shapes. (a) Trapezoid. (b) Gaussian function. (c) Isosceles triangle. (4 marks)

b) Define Fuzzy Propositions. Explain different fuzzy propositions. (10 marks)

Module II

13. a)Defuzzify the following output membership function using centroid method:
0/0, 0.3/1 , 0.3/3.5 , 0.5/4 , 0.5/5.5 , 1/6 , 1/7 , 0/8. (4 marks)

b) In the following fuzzy system to predict power demand of a state, the following input membership functions are used:

Temperature :triang(0 10 20), triang(10 25 40), triang(30 40 50). (for low, medium and high)
Month :triang(0 2 4), triang(2 6 10), triang(8 10 12), (for summer, rainy and winter)
The oputput membership function is
Power demand :triang(0 250 400), triang(250 500 750), triang(600 750 1000), (for low, medium and high)
The rules are
1) If temp is low and month is winter, demand is low
2) If temp is medium and month is rainy, demand is medium
3) If temp is medium and month is winter, demand is high.
For a temperature of 16 and for a month of 9.5, find the power demand using centroid defuzzification method. (5 marks)
c) Do problem 2b using weighted average defuzzification method. (5 marks)

14. a) Explain any five defuzzification methods. (5 marks)
b) What are the different steps involved in the design of fuzzy logic controller? Explain with a typical example. (9 marks)

Module III

15. a) A perceptron is used to classify the inputs and targets mentioned below:
{ p1 = [1;1], t1 =[0;0]}, {p2 = [1;2], t2 = [0;0]}, { p3 = [2;-1], t3 = [0;1]}, p4 = [2;0], t4 = [0;1]},
{p5= [[-1;2], t5 =[1 0]}, {p6=[-2;1], t6=[1;0]}, {p7=[-1;-1], t7=[1;1], {p8 = [-2;-2], t8=[1;1]}

Train the network with the initial weight and bias matrices of [1 0;0 1] and [1;1] respectively. (4 marks)
b) A 1-2-1 network with log sigmoid transfer function in the hidden layer and linear transfer function in the output layer is used to model a function which gives an output value of 1.261 for an input of 1. For the initial weight and bias matrices

$$\mathbf{W}^1(0) = \begin{bmatrix} -0.27 \\ -0.41 \end{bmatrix}, \mathbf{b}^1(0) = \begin{bmatrix} -0.48 \\ -0.13 \end{bmatrix}, \mathbf{W}^2(0) = \begin{bmatrix} 0.09 & -0.17 \end{bmatrix}, \mathbf{b}^2(0) = \begin{bmatrix} 0.48 \end{bmatrix}$$

of
find the weight and biases after one iteration of back propagation. (5 marks)
c) Realize an Exclusive-OR gate using a combination of Perceptron neurons. (5 marks)
16. a) State the significance of error portion δkand δjin Back Propagation Network. (5 marks)
b) Explain the stage involved in Back Propagation Algorithm? (9 marks)

Module IV

17. a) Draw the flow chart of Genetic Algorithm based optimization process and enlist the steps involved and the methods available in each step. (4 marks)
b) Do one iteration of finding the maximum of the following function using Genetic Algorithm:
Maximize $Y = 800 - 62.83(2D + 0.91D^{-0.2})$, $0 < D < 6.3$

Choose (0.3, 1.5, 3, 5) as initial population and make 5^{th} position in single point crossover. Do mutations at 5^{th}, 17^{th} and 23^{rd} positions. (5 marks)

c) It is required to solve the equation a+2b+3c+4d = 30 after converting this to a maximization problem using Genetic Algorithm. Do one iteration. (5 marks)

18. a) Explain various coding techniques in GA with examples? (5 marks)

b) Explain Genetic Fuzzy Rule Based systems? (9 marks)

Module V

19. a) Explain the use of Genetic Algorithm in training a neural network (4 mark)

b) Explain how the performance of a PI controller can be improved with fuzzy system. (5 marks)

c) Explain the concept of Neuro Genetic Systems (5 marks)

20. a) Explain the characteristics and different classifications of a neuro-fuzzy hybrid system. (10 marks)

b) Explain Genetic Fuzzy Rule Based systems? (4 marks)

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Syllabus

Module 1

Introduction to fuzzy logic: Fuzzy Sets-Fuzzy set operations-Fuzzy Relations-Cardinality of fuzzy relations-operations on Fuzzy Relations-Properties of Fuzzy relations-properties of fuzzy relations-Membership functions-features of membership functions-Fuzzification-methods of membership value assignments-fuzzy rule base

Module 2

Defuzzification-Defuzzification methods-Fuzzy logic controller (Block diagram).artificial neural networks. Basic concepts-Neural network architecture-Single layer feed forward network-Multilayer feed forward network-Recurrent networks

Module 3

Characteristics of Neural networks- Learning methods. Perceptron networks-Back propagation networks-Radial base function network-Hopfield network-Kohonenself-organising maps.

Module 4

Fundamentals of genetic algorithms: Basic concepts-working principle-encoding-different methods-fitness function-reproduction-different methods. Genetic modelling- inheritance-cross over mutation-convergence of genetic algorithm.

Module 5

Hybrid systems: Neural network, fuzzy logic and genetic algorithm hybrids-Neuro fuzzy hybrids-neuro genetic hybrids-Fuzzy genetic hybrids.

Text Books:

1. S. Haykins, *Neural networks a comprehensive foundation*, Pearson Education.
2. L. Fausett, *Fundamentals of Neural Networks*, Prentice Hall 1994.
3. Timothy J Ross, *Fuzzy Logic with Engineering Applications*, McGrawHill, New York.

Reference Books

1. S. N. Sivanandam, S. N. Deepa, *Principles of Soft Computing*, Wiley India Pvt. Ltd.
2. S. Rajasekharanand and G.A. VijayalakshmiPai, Neural Network, *Fuzzy Logic and Genetic Algorithms- Synthesis and Applications*, Prentice Hall of India.
3. D.E. Goldberg, *Genetic Algorithms in search Optimization and Machine Learning*, Pearson Education.
4. AmitKonar, *Artificial Intelligence and Soft Computing*, First Edition,CRC Press, 2000.
5. John Yen, Reza Lengari, Fuzzy Logic- Intelligence, Control and Information, Pearson Education.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures (Hrs.)
1	**Fuzzy logic (9 Hrs)**	
1.1	Introduction to fuzzy logic: Fuzzy Sets-Fuzzy set operations	2
1.2	Fuzzy relations-Cardinality of fuzzy relations-operations on Fuzzy Relations-Properties of Fuzzy relations-properties of fuzzy relations-	3
1.3	Membership functions-features of membership functions	2
1.4	Fuzzification-methods of membership value assignments-fuzzy rule base	2
2	**Defuzzification (9 Hrs)**	
2.1	Defuzzification methods	2
2.2	Fuzzy logic controller (Block diagram).	2
2.3	Artificial neural networks. Basic concepts	2
2.4	Neural network architecture-Single layer feed forward network-Multilayer feed forward network-Recurrent networks	3
3	**Characteristics of Neural networks (9 Hrs)**	
3.1	Characteristics of Neural networks- Learning methods.	2
3.2	Perceptron networks-Back propagation networks	2
3.3	Radial base function network-Hopfield network	3
3.4	Kohonen self-organising maps	2
4	**Fundamentals of genetic algorithms (10 Hrs)**	
4.1	Fundamentals of genetic algorithms- Basic concepts-working principle	2
4.2	Encoding-different methods	2
4.3	Fitness function-reproduction-different methods.	3
4.4	Genetic modelling- inheritance-cross over mutation-convergence of	3

	genetic algorithm.	
5	**Hybrid systems (8 Hrs)**	
5.1	Hybrid systems: Neural network, fuzzy logic and genetic algorithm hybrids	3
5.2	Neuro fuzzy hybrids-neuro genetic hybrids	3
5.3	Fuzzy genetic hybrids.	2

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
KTU
Estd.
2014

SEMESTER VI

CHT 302	MASS TRANSFER OPERATIONS - II	CATEGORY	L	T	P	CREDIT
		PCC	3	1	0	4

Preamble: Objective of this course is to impart fundamental concepts of mass transfer operations such as distillation, liquid extraction, leaching and membrane separation processes. This course also explains how to quantify, formulate, and solve engineering problems involving different mass transfer operations like distillation, liquid-liquid extraction, leaching and membrane separation processes.

Prerequisite: Basic knowledge in Chemical Process Principles

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

CO1	Explain boiling point diagrams, relative volatility and differentiate various types of distillation techniques.
CO2	Design a fractionation column using McCabe – Thiele method and apply it for various reflux conditions.
CO3	Apply Ponchon - Savarit method to determine the number of stages required for a given separation in a fractionator for different reflux conditions and to understand rectification in packed columns.
CO4	Explain the theory of extraction and design of single stage and multi-stage extraction processes with an understanding of construction and working of extractors.
CO5	Explain the theory of leaching and design of single stage and multi-stage leaching processes with an understanding of construction and working of leaching equipments.
CO6	Differentiate among various types of membrane separation 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
CO 1	3	--	--	--	--	--	--	--	--	--	--	--
CO 2	3	3	3	--	--	--	--	--	--	--	--	--
CO 3	3	3	3	--	--	--	--	--	--	--	--	--
CO 4	3	3	3	2	--	--	--	--	--	--	--	--
CO 5	3	3	3	2	--	--	--	--	--	--	--	--
CO 6	3	--	--	--	--	--	--	--	--	--	--	--

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	20
Understand	10	10	20
Apply	20	20	40
Analyze	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): Explain boiling point diagrams, relative volatility and differentiate various types of distillation techniques.

1. Define relative volatility and explain its significance.
2. Define Differential distillation and derive the material balance equation for differential distillation.
3. Show that the relative volatility of an ideal binary system is equal to the ratio of vapor pressure of two components.

Course Outcome 2 (CO2): Design a fractionation column using McCabe – Thiele method and apply it for various reflux conditions.

1. A continuous distillation column is to separate 50 kmol/hr of feed mixture having 65% Benzene (A) and 35% Toluene (B). Top product contains 95% Benzene and Bottom product contains 95% Toluene (by mole). Feed is saturated liquid at its bubble point.

Average relative volatility is 2.44. If reflux ratio R= 2.25 R_{min}, determine feed tray location and number of theoretical stages by McCabe -Thiele method.

2. Define reflux ratio. Explain how to calculate the minimum reflux ratio when feed is a saturated vapour.
3. Define constant molal overflow. Outline the McCabe-Thiele design method for obtaining number of theoretical trays by graphical method clearly mentioning its assumptions.

Course Outcome 3 (CO3): Apply Ponchon - Savarit method to determine the number of stages required for a given separation in a fractionator for different reflux conditions and to understand rectification in packed columns.

1. Explain the various steps in determining number of stages in a distillation column by Ponchon - Savarit method
2. Explain the concept of net flow and difference point
3. Explain extractive distillation with the help of an example.

Course Outcome 4 (CO4): Explain the theory of extraction and design of single stage and multi- stage extraction processes with an understanding of construction and working of extractors.

1. Nicotine in a water solution containing 1% nicotine is to be extracted with kerosene at 25^0C. Kerosene and water are insoluble. Determine the percentage extraction of nicotine if 1000 kg of feed solution is extracted in a single stage operation using 1500 kg solvent. What would be the percentage extraction if three theoretical stages are used with 500 kg solvent in each stage? Equilibrium data expressed as kg nicotine/ kg liquid are as follows:

X	0.001	0.0025	0.005	0.0075	0.00998	0.0204
Y	0.0008	0.00196	0.0046	0.0069	0.0091	0.0187

2. Explain different factors to be considered for selection of solvent in extraction operations.
3. Explain the principle and working of mixer settler cascade

Course Outcome 5 (CO5): Explain the theory of leaching and design of single stage and multi-stage leaching processes with an understanding of construction and working of leaching equipments.

1. Oil seed containing 20% oil is extracted in counter current plant and 90% of the oil is recovered to get a solution containing 50% oil. If the seeds are extracted with fresh solvent and 1kg solution is removed in the underflow in association with every 2kg of insoluble matter. Determine the number of ideal stages required.
2. Discuss the factors affecting leaching.
3. List out the applications of leaching.

Course Outcome 6 (CO6): Differentiate among various types of membrane separation processes.

1. What are the advantages of membrane separation processes over conventional separation processes?

2. Enlist the factors affecting membrane performance.
3. Write a note on ultrafiltration.

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Model Question Paper

QP CODE: **PAGES: 3**

Reg No: _____Name: _____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SIXTH SEMESTER B. TECH DEGREE EXAMINATION,MONTH & YEAR

Course Code: CHT302

Max. Marks: 100 Duration: 3 Hours

MASS TRANSFER OPERATIONS - II

PART – A

Answer All the Questions (10 x 3 = 30)

1. The relative volatility of a binary system is 4.13. Find out x – y data.
2. Derive Rayleigh equation for a binary mixture.
3. Define reflux ratio and differentiate between minimum reflux ratio and total reflux ratio.
4. Derive q-line equation for feed tray location.
5. Differentiate between Packed Towers and Tray Towers.
6. Define selectivity of solvent used in liquid extraction.
7. Explain briefly the system of three liquids with one pair partially soluble in case of liquid extraction.
8. List out the various factors which limit the rate of solid-liquid extraction.
9. Write a short note on heap leaching.
10. Outline the industrial applications of leaching.

PART – B

Answer one full question from each module (5 x 14 = 70)

Module 1

11. (a) A liquid mixture containing 40 mole percent of n-heptane and 60% n-octane (α = 2.16) is subjected to differential distillation at atmospheric pressure with 60% (mole) of the liquid distilled. Compute the composition of the Distillate and Residue.

    (b) A fractionation column has been installed to distillate 5000 kg/hr of a mixture of 50 % methanol & 50% water (by weight). The overhead and bottom products are found to contain 95 % methanol and 1 % methanol respectively. Carry out material balances.

    Data: Mol. wt. of methanol: 32 and Mol. wt. of water: 18. **(7+7 = 14 Marks)**

OR

12. (a) Define relative volatility and explain its significance.

(b) Define Differential distillation and derive the material balance equation for differential distillation.

(c) Show that the relative volatility of an ideal binary system is equal to the ratio of vapor pressure of two components. **(3+6+5 = 14 Marks)**

Module II

13. (a) Derive Fenske's equation for the minimum number of theoretical stages.

(b) Define reflux ratio. Explain how to calculate the minimum reflux ratio when feed is a saturated vapour. **(7+7 = 14 Marks)**

OR

14. A continuous distillation column is to separate 50 kmol/hr of feed mixture having 65% Benzene (A) and 35% Toluene (B). Top product contains 95% Benzene and Bottom product contains 95% Toluene (by mole). Feed is saturated liquid at its bubble point. Average relative volatility is 2.44. If reflux ratio R= 2.25 R_{min}, determine feed tray location and number of theoretical stages by McCabe -Thiele method. **(14 Marks)**

Module III

15. (a) Define an azeotrope. Explain the advantages, disadvantages and industrial application of azeotropic distillation with suitable example.

(b) Explain the concept of net flow and difference point **(8+6 =14 Marks)**

OR

16. Explain the various steps in determining number of stages in a distillation column by Ponchon - Savarit method. **(14 Marks)**

Module IV

17. (a) Explain with neat sketches any two extraction equipments used in chemical industries.

(b) Explain different factors to be considered for selection of solvent in extraction operations. **(8+6 = 14 Marks)**

OR

18. Nicotine in a water solution containing 1% nicotine is to be extracted with kerosene at 25 0C. Kerosene and water are insoluble. Determine the percentage extraction of nicotine if 1000 kg of feed solution is extracted in a single stage operation using 1500 kg solvent.Calculate the percentage extraction if three theoretical stages are used with 500 kg solvent in each stage. Equilibrium data expressed as kg nicotine/ kg liquid are as follows:

X	0.001	0.0025	0.005	0.0075	0.00998	0.0204
Y	0.0008	0.00196	0.0046	0.0069	0.0091	0.0187

(14 Marks)

Module V

19. (a) Explain the working of Shank's system in detail with schematic diagram.

(b) Enlist the advantages of membrane separation processes over conventional separation processes. **(**7+7 **= 14 Marks)**

OR

20. (a) Oil seed containing 20% oil is extracted in counter current plant and 90% of the oil is recovered to get a solution containing 50% oil. If the seeds are extracted with fresh solvent and 1kg solution is removed in the underflow in association with every 2kg of insoluble matter. Determine the number of ideal stages required.
    (b) Enlist the factors affecting membrane performance. **(9+5 = 14 Marks)**

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Syllabus

Module 1 (8 Hrs.)

Distillation- Vapour-Liquid Equilibria, boiling- point diagram and equilibrium curves, relative volatility, application of Raoult's law. Distillation methods- flash distillation, Simple distillation or Differential distillation, Binary distillation, Steam distillation, Problems.

Module 2 (10 Hrs.)

Fractionation of binary mixtures, Principle of fractionation, Fractionation in plate columns, condensers and reboilers. Material and energy balance, Design of fractionation columns by McCabe - Thiele method - basic assumptions, feed quality and feed line, number of plates, feed plate location, total reflux, minimum reflux , optimum reflux, plate efficiency, cold reflux and open steam.

Module 3 (8 Hrs.)

Enthalpy composition diagrams, Concept of net flow and difference point, Ponchon–Savarit method– material and enthalpy balance, number of plates, feed plate location, minimum reflux conditions. Rectification in packed columns, height of packed towers.
Azeotropic and Extractive distillation (qualitative treatment only).

Module 4 (10 Hrs.)

Extraction –applications, ternary equilibria on triangular coordinate system,mixer rule, distribution curve, selectivity, choice of solvent. Single-stage and multistage extraction operations - Calculations for immiscible systems and partially miscible systems.
Construction and working of mixer -settler cascades, sieve-tray columns, agitated towers, pulse columns and centrifugal extractors.

Module 5 (9 Hrs.)

Leaching – Rate of leaching, factors affecting rate of leaching. Working principles of leaching equipment- Shank's system- thickeners, classifiers and moving bed leaching equipment.
Leaching equilibrium - constant underflow - variable underflow Single stage and multistage leaching.
Membrane separation processes – classification – types of membranes: flat, spiral wound, hollow fibre -concentration polarization – ultrafiltration.

Text Books:

1. Treybal R.E., Mass Transfer Operations, McGraw Hill.
2. Binay K Dutta, Principles of Mass Transfer & Separation Processes, PHI Learning Private Limited.

Reference Books:

1. K.V. Narayanan and B. Lakshmikutty.Mass Transfer-Theory and Applications,CBS Publishers.
2. N. Anantharaman and K.M.Meera Sheriffa Begum, Mass Transfer-Theory and Practice, PHI Learning Private Limited (2011) New Delhi.
3. McCabe W.L., Smith J.C. &Harriot P., Unit Operations in Chemical Engineering, McGraw Hill.
4. Geankoplis C.J., Transport Processes and Unit Operations, Prentice Hall India
5. Coulson J.M. & Richardson J.F., Chemical Engineering, Vol. II, ELBS, Pergamon

Course Contents and Lecture Schedule:

No.	Details	No. of Lectures
1	**Module 1**	**8**
1.1	Introduction to distillation, Vapor-liquid equilibrium, T-x-y diagram, bubble and dew point calculations	2
1.2	Relative volatility, equilibrium curves - application of Raoult's law	1
1.3	Ideal and non -ideal solutions, azeotropes	1
1.4	Batch distillation and equilibrium flash vaporization	2
1.5	Steam distillation	1
1.6	Differential distillation	1
2	**Module II**	**10**
2.1	Fractionation - plate columns for distillation –condensers – reboilers	1
2.2	Principles of rectification - material and energy balance	1
2.3	Design of fractionation columns by McCabe - Thiele method - basic assumptions - feed quality and feed line	1
2.4	Design of fractionation columns by McCabe - Thiele method - number of plates- feed plate location.	2
2.5	Design of fractionation columns by McCabe - Thiele method - number of plates - total reflux&minimum reflux.	2
2.6	Design of fractionation columns by McCabe - Thiele method - number of plates - optimum reflux, plate efficiency.	2
2.7	Design of fractionation columns by McCabe - Thiele method - cold reflux, open steam.	1
3	**Module III**	**8**
3.1	Enthalpy – composition diagrams, Ponchon–Savarit method– difference points and reflux ratio	2
3.2	Ponchon–Savarit method - number of plates, feed plate location,	3

	minimum reflux conditions.	
3.3	Rectification in packed columns - height of packed towers	2
3.4	Azeotropic and extractive distillation (qualitative treatment only).	1
4	**Module IV**	**10**
4.1	Extraction - applications - ternary equilibria on triangular coordinate system, single stage extraction	2
4.2	Mixer rule -distribution curve – selectivity, choice of solvent	1
4.3	Single-stage and multistage extraction operations - Calculations for immiscible systems.	2
4.4	Single-stage and multistage extraction operations - Calculations for partially miscible systems.	3
4.5	Construction and working of mixer - settler cascades, sieve-tray columns, agitated towers, pulse columns and centrifugal extractors.	2
5	**Module V**	**9**
5.1	Leaching -factors affecting rate of leaching. Leaching equilibrium - constant underflow - variable underflow Single stage and multistage leaching.	4
5.2	Working principles of leaching equipment- Shank's system- thickeners, classifiers and moving bed leaching equipment.	2
5.3	Membrane separation processes – classification – types of membranes: flat, spiral wound, hollow fibre -concentration polarization – ultrafiltration.	3

CHT304	TRANSPORT PHENOMENA	CATEGORY	L	T	P	CREDIT
		PCC	3	1	0	4

Preamble: This course introduces coupling between three transport phenomena, momentum, heat and mass transport with applications in various disciplines in engineering and science, and will demonstrate to the students the common mathematical structure of transport problems. The course will deal with flow problems involving Newtonian and non-Newtonian fluids, solid-state heat conduction and convection, binary diffusion with or without chemical reaction. To give basic axioms of conservations namely conservation of momentum, energy and mass

Prerequisite: Basic knowledge in calculus, momentum, heat and mass transfer

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

CO 1	Explain the mechanisms of momentum, heat and mass transfer
CO 2	Predict the transport coefficients of gases from basic physical variables
CO 3	Solve industrial problems involving isothermal steady state momentum transfer in simple geometries using shell momentum balance , equations of change and boundary conditions
CO 4	Obtain analytical solutions of selected simple engineering steady state problems of heat transfer using shell energy balance and equations of change
CO 5	Analyze simple steady state diffusion problems using shell mass balance

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											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	20
Understand	10	10	20
Apply	20	20	40
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. Explain the mechanism of momentum transfer between two parallel plates in which one is moving and the other stationary.
2. Prove that the sum of the molar diffusion fluxes relative to the molar average velocity is zero in any mixture.
3. Explain the analogies among transport mechanisms.

Course Outcome 2 (CO2)

1. For gases at low density, viscosity increases with increase in temperature, justify the statement.
2. Using Chapman-Enskog formula compute the thermal conductivity of neon at 1atm and 373.2K. Given: Lennard-Jones characteristic diameter of the neon molecule=2.789ºA, molecular weight of neon molecule=20.183. Collision function Ω_μ=Ω_k=0.821.
3. What bulk properties are related to Stokes – Einstein equation? Check the dimensional consistency of equation.

Course Outcome 3(CO3):

1. A fluid of constant density and viscosity is in a cylindrical container of radius R .The container is caused to rotate about its own axis (vertical) at an angular velocity Ω. Find the shape of the free surface at steady state.

2. Write the Navier-Stokes equation. Under what conditions equation of motion for Newtonian fluids reduces to Navier-Stokes equation.
3. Sketch the momentum flux and velocity distributions for the flow through cylindrical tubes.

Course Outcome 4 (CO4):

1. Derive expression for temperature profile for the flow of incompressible Newtonian fluid between 2 co-axial cylinders, in which the outer cylinder rotates and inner one is held stationary.

2. A heated sphere of radius R is suspended in a large, motionless body of fluid. It is desired to study the heat conduction in the fluid surrounding the sphere in the absence of convection.

   (a) Set up the differential equation describing the temperature T in the surrounding fluid as a function of r, the distance from the center of the sphere. The thermal conductivity k of the fluid is considered constant.

   (b) Integrate the differential equation and use these boundary conditions to determine the integration constants: at r = R, T = T_R; and at r = ∞, T = T_∞.

   (c) From the temperature profile, obtain an expression for the heat flux at the surface. Equate this result to the heat flux given by "Newton's law of cooling" and show that a dimensionless heat transfer coefficient (known as the Nusselt number) is given by Nu $= \frac{hD}{k} = 2$,in which D is the sphere diameter

3. Derive expressions for heat flux, temperature distribution and average temperature rise at steady state in an electrical wire of circular cross section. The rate of heat production per unit volume is given by $Se=I^2/K_e$. I is the current density amperes/cm2 and k_e is the electrical conductivity ohm^{-1} cm^{-1}. Assume that the outer surface of the conductor is maintained at constant temperature. Also find the heat out flow from the surface.

Course Outcome 5 (CO5):

1. A gaseous phase reaction $2A \rightarrow A_2$ is taking place on the surface of a catalyst. Assume that each catalyst particle is surrounded by a stagnant gas film through which A has to diffuse to reach catalyst. Using suitable assumptions develop an expression for the local rate of conversion and obtain the concentration profile in the gas film and molar flux through the film. Sketch the concentration profile.

2. Diffusivity of a gas pair O_2-CCl_4 is determined by observing the steady state evaporation of CCl_4 into a tube containing O_2. The distance between CCl_4 liquid level and the top of the tube is 17.1cm. The total pressure on the system is 755mmHg and temperature is 273K.The vapour pressure of CCl_4 at that temperature is 33 mmHg. The cross sectional area of diffusion tube is $0.82cm^2$. It is found that $0.0208cm^3$ of CCl_4 evaporate in a 10hr period after steady state has been achieved. What will be diffusivity of gas pair CCl4-O2. Given that density of CCl4=1.59g/cm3.

3. Derive the equation of continuity for a binary mixture.

Model Question Paper

QP CODE: **PAGES: 3**

Reg No: _____Name: _____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SIXTH SEMESTER B. TECH DEGREE EXAMINATION,MONTH & YEAR

Course Code: CHT 304

Max. Marks: 100 Duration: 3 Hours

TRANSPORT PHENOMENA

PART – A

Answer **all** questions. Each question carries **3** marks

1. Compute the viscosity of CO2 at 200K and 1 atm. Given **Ωμ** =1.548, σ =3.996A°**.**
2. Describe the relationship between thermal conductivity and viscosity of gases.
3. An oil has a kinematic viscosity of 2x10-4 m^2 /s and a density of 0.8x103 kg/m3. If we want to have a falling film of thickness of 2.5 mm on a vertical wall, what should the mass rate of flow of the liquid be?
4. Give the vector form of the Navier-stokes and Euler equations and explain the significance of each term.
5. The maximum temperature rise in a current carrying conductor is $I^2 R^2 /4kk_e$ .Obtain the following equation representing the relationship between the voltage drop E and the maximum temperature rise within a current carrying conductor of radius R, current density I, length L, thermal conductivity k and electrical conductivity k_e. $E = 2\frac{L}{R}\sqrt{\frac{k}{keT_0}}\sqrt{T_0(T_{max} - T_0)}$. Here T_0 and T_{max} are the surface temperature and centre temperature of the wire.
6. What is transpiration cooling? and give applications of transpiration cooling.
7. Write the different types of concentrations, velocities and fluxes used to describe diffusion in a multi-component mixture.
8. Explain the conservation equation used in momentum, energy and mass transport.
9. State the procedure to solve steady state mass transfer problem using shell momentum balance and list the important boundary conditions used to solve it.
10. Explain briefly about the diffusion of component ‘A’ through a stagnant “B’ within the liquid vapour interface maintained at a fixed position and obtain an expression for the molar flux of component A.

(10x3=30 marks)

PART B

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

MODULE-I

11. (a) Estimate the viscosity of N2 at 50°C and 854 atm. Given M=28,Pc =33.5 atm; Tc = 126.2K and μr =2.39. Also calculate Tr and Pr. **(4)**

(b) Establish a correlation for gas viscosity with temperature and pressure using kinetic theory of gases. List valid assumptions. **(10)**

OR

12. (a) Compute the thermal conductivity of argon at 80° C and 1 atm pressure using Chapman-Enskog model. The molecular weight of argon is 39.54, σ =3.4180 A° and Ω_k =1.039. **(4)**

(b) Calculate the thermal conductivity of a mixture containing 20 mol% CO_2 and 80 mol% H_2 at 1 atm and 300K. Given

	Thermal Conductivity(Cal/s.cm.K)	Viscosity(g/s.cm)
CO2	$383x10^{-7}$	$1495x10^{-7}$
H2	$4250x10^{-7}$	$896x10^{-7}$

(10)

MODULE-II

13. Derive the momentum flux and velocity distribution, average velocity and volumetric flow rate equations for a laminar fluid flowing through an annulus of inner radius KR, outer radius R and length L. **(14)**

OR

14. Determine the velocity and shear stress distribution for the tangential laminar flow of an incompressible fluid between two vertical coaxial cylinders. The outer one is rotating with an angular velocity Ω_0. Also determine the viscosity of the fluid. **(14)**

MODULE-III

15. Consider a spherical form of nuclear fissionable material of radius R^F and is surrounded by aluminium cladding of radius R^C .The purpose of cladding is to absorb neutrons. Inside the fuel element ,due to fission thermal energy is produced (S_n).This source will not be uniform throughout the sphere of fissionable material, it will be smallest at the centre of the sphere. Therefore source is assumed as a parabolic function. $Sn = Sn_0 [1+b(r/ R^F)^2]$, where Sn_0 is the volume rate of production at the

centre of the sphere, b-dimensionless constant. Derive the expression for temperature distribution in the aluminium cladding and fissionable material. **(14)**

OR

16. Determine the temperature distribution in an incompressible Newtonian fluid held between two co-axial cylinders, the outer of which is rotating at a steady angular velocity Ω_0. The inner cylinder has a radius of kR and that of the outer cylinder is R. Consider that the wetted surfaces of the outer and inner cylinders are at temperature T_0 and T_i .Assume steady laminar flow and neglect the temp. dependence of μ,ρ and k.

(14)

MODULE-IV

17. (a) Predict the value of D_{AB} for the system CO-CO_2 at 296K and 1 atm total pressure. Given , Ω_{DAB} =1.067, σ_{AB} =3.793A^0 . **(4)**

(b) For a binary mixture of A&B using the basic definitions of concentrations, velocities and fluxes, show that the mass fraction 'w_A' is related to mole fraction 'x_A' by

(i) $w_A = \frac{x_A M_A}{x_A M_A + x_B M_B}$ (ii) $dw_A = \frac{M_A M_B \, dx_A}{\left(x_A M_A + x_B M_B\right)^2}$

(iii) $dx_A = \frac{dw_A}{M_A M_B \left(W_A/M_A + W_B/M_B\right)^2}$ (iv) $n_A + n_B = \rho V$

Where, n_A, n_B : mass flux relative to fixed spatial co-ordinates

ρ : Density

V : Mass average velocity

M_A , M_B : Molecular weights o A &B respectively

(10)

18. Explain the theory of diffusion of liquid and establish the correlation developed by Wilke and Chang for diffusivity estimation. Also calculate the liquid diffusion coefficient of ethanol in a dilution solution of water at 10oC. The molecular volume of ethanol is 59.2 cm3/gmol. Use of the following data: μ of ethanol at 10oC= 1.45 Cp. The association parameter for water is 2.6.

(14)

MODULE-V

19. A liquid droplet A of radius 'r_1' is evaporating into an isothermal film of gas B surrounding the liquid. The outer surface of the gas film is at a distance 'r_2' from the centre of the liquid droplet. Assume that the concentration of 'A' in terms of mole fraction of A at the liquid-gas interface and at the outer surface of the gas film are

constant at x_{A1} and x_{A2} respectively. Assume that gas 'B' does not dissolve in the liquid. Use suitable assumptions and develop mass balance equations and obtain the concentration profile of 'A' in the gas film and also the molar flux of 'A' at the gas-liquid interface and rate of evaporation of liquid. **(14)**

OR

20. A slow catalytic dimerization reaction, 2A → B is taking place on the surface of a catalyst inside a catalytic reactor. The effective gas film thickness on the catalyst surface may be taken as ' δ'. Starting from a mass balance, develop the expressions for the concentration profile of the component A and the molar flux of A through the gas film. Using suitable assumptions. **(14)**

Syllabus

Module 1 (7hrs)

Prediction of transport coefficients – viscosity and thermal conductivity. Viscosity and the mechanisms of momentum transfer: Generalization of Newton's law of viscosity, pressure and temperature dependence of viscosity of gases and liquids, prediction of viscosity of gases: Rigid sphere model and rigorous models, Numerical problems.

Energy Transport: Thermal conductivity and the mechanism of energy transport- prediction of thermal conductivity of gases, effect of temperature and pressure on thermal conductivity of gases, relationship between thermal conductivity and viscosity of gases. Thermal conductivity of solids, relationship between thermal and electrical conductivity of solids, Numerical problems.

Module 2 (12hrs)

Shell momentum balance - boundary conditions - application of shell balance to simple flow systems - falling film -flow of a Newtonian fluid in between two slits formed by two flat plates flow through tube - flow through annulus - flow of two adjacent immiscible fluids. General transport equations for momentum - derivation of continuity equation and equation of motion in rectangular coordinates - NavierStoke's equation and Euler equation - transport equations in curvilinear coordinates (no derivation) - application of transport equations to steady flow problems - flow through tube - tangential annular flow - rotating liquid - cone and plate viscometer.

Module 3 (11 hrs)

Shell energy balance - boundary conditions - application of shell balance to heat conduction problems - conduction with electric, nuclear and viscous heat sources and other similar heat conduction problems, use of shell heat balances in variable thermal conductivity systems to derive temperature and heat flux profiles, cooling fins with insulated tip condition. Equations of energy in rectangular and curvilinear coordinates (no derivation) - application to steady-state heat transfer problems - tangential flow in annulus with viscous heat generation - flow of nonisothermal film - transpiration cooling

Module 4 (7hrs)

Diffusivity and the Mechanism of Mass Transport: Definition of concentrations, velocities and mass/molar fluxes, interrelationship between fluxes. Fick's law of diffusion, kinetic theory of diffusion in gases at low density, theory of ordinary diffusion in liquids. Prediction of diffusivity of gases, effect of temperature, pressure and composition on diffusivity, analogies between heat, mass and momentum transfer.

Module 5 (8hrs)

Shell mass balance - boundary conditions - diffusion through stagnant gas - diffusion with heterogeneous and homogeneous chemical reaction - diffusion and chemical reaction in porous catalyst – other similar diffusion problems, equation of continuity for binary mixtures in rectangular coordinates.

Note: For the University examinations, students are permitted to take tables of equations of continuity, motion, components of shear tensor and energy inside the examination hall.

Text Books

- Bird R.B., Stewart W.C and Lightfoot F.N, Transport phenomena, John Wiley & Sons..

Reference Books

1. Theodore L, Transport Phenomena for Engineers by, International text book Company, U.S.A
2. Geankoplis, Transport processes and unit operations, 3rd, , PHI, 1997.
3. Welty, Wicks and Wilson, Fundamentals of Heat, Momentum and Mass Transfer, John Wiley.
4. John C Slattery, Momentum, Energy and Mass transfer in continua, McGraw Hill, Co.
5. Robert S. Brodkey and Harry C Hersing, Transport Phenomena a Unified approach, McGraw Hill Book Co.
6. Bennet C U and Myers J E, Momentum, Heat and Mass Transfer, Tata McGraw Hill Publishing Co.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Module 1 (7 Hrs.)**	
1.1	Newton's law of viscosity, pressure and temperature dependence of viscosity of gases and liquids	2
1.2	prediction of viscosity of gases and numerical problems	2
1.3	Energy Transport	3
2	**Module 2 (12 Hrs.)**	
2.1	Application of shell balance to simple flow systems	6
2.2	derivation of continuity equation and equation of motion in rectangular coordinates	2
2.3	application of transport equations to steady flow problems	4
3	**Module 3 (11 Hrs.)**	
3.1	application of shell balance to heat conduction problems	6
3.2	application of equation of energy to steady-state heat transfer problems	5
4	**Module 4 (7 Hrs.)**	
4.1	Diffusivity and the mechanism of mass transport	1
4.2	Definition of concentrations, velocities and mass/molar fluxes, interrelationship between fluxes	2
4.3	kinetic theory of diffusion in gases at low density and theory of ordinary diffusion in liquids	4
5	**Module 5 (8 Hrs.)**	
5.1	Shell mass balance	6
5.2	equation of continuity for binary mixtures in rectangular coordinates	2

CHT 306	CHEMICAL TECHNOLOGY	CATEGORY	L	T	P	CREDIT
		PCC	3	1	0	4

Preamble: The subject reveals the study of producing pharmaceuticals, chemicals, and petroleum products in laboratories and processing plants. It helps the student to develop new chemical products and processes, test processing equipment and instrumentation, gather data, and monitor quality. Also the study of chemical technology will enable the students to do research, design, and construct safe, sustainable machinery to produce a wide range of valuable items.

Prerequisite: Basic knowledge in unit processes and unit operations.

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

CO 1	Sketch and explain the process flow diagram for the manufacture of inorganic chemicals.
CO 2	Explain and draw the process flow diagram of various processes for the production Chlor-alkali and fertiliser industries.
CO 3	Draw and explain the process flow diagram for production of carbon chemicals, surface coatings and cement.
CO 4	Sketch and explain the process flow diagram for the manufacture of glass, pesticides and natural products like soap, pulp and paper etc.
CO 5	Explain the food processing, production of alcohol and pharmaceutics
CO 6	Explain various process engineering technologies and process flow sheeting methods and select the best process for a product among the alternative methods available in the process industry.

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										
CO 3	3	2										
CO 4	3	2										
CO 5	3	2										
CO 6	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): Sketch and explain the process flow diagram for the manufacture of inorganic chemicals.

1. List out the uses of dry CO2.
2. Discuss Linde's process for manufacture of O_2 and N_2. Discuss in brief the uses and properties of nitrogen and oxygen gases.
3. With a process flow diagram, describe the manufacture of sulfuric acid by DCDA process

Course Outcome 2 (CO2): Explain and draw the process flow diagram of various processes for the production Chlor-alkali and fertiliser industries.

1. Write short notes on compound fertilizers
2. Write down application of Soda ash and Caustic soda
3. Enlist various processes used for manufacturing of Caustic Soda. Explain in detail the mercury cell process for the production of Caustic Soda.

Course Outcome 3(CO3): Draw and explain the process flow diagram for production of carbon chemicals, surface coatings and cement.

1. Discuss Settling & Hardening of Cement in brief
2. State factors effecting setting time of cement.
3. With a neat flow chart, discuss the production of carbon black.

Course Outcome 4 (CO4): Sketch and explain the process flow diagram for the manufacture of glass, pesticides and natural products like soap, pulp and paper etc.

1. Briefly discuss Kraft (sulfate) process of pulping and compare with sulfite process.
2. Stating the classification of commercial glasses, explain the manufacture of flat glass.
3. List out 4 major pesticides used in india and their effects in human being.

Course Outcome 5 (CO5): Explain the food processing, production of alcohol and pharmaceutics

1. Explain various food processing methods in detail.
2. With a neat flow diagram, explain the production of industrial alcohol.
3. List the names of pharmaceutical industry in india.

Course Outcome 6 (CO6): Explain various process engineering technologies and process flow sheeting methods and select the best process for a product among the alternative methods available in the process industry.

1. Compare wet process and electric process in phosphoric acid manufacture.
2. Select suitable method for the production of pulp. List the advantages of the process over other processes.
3. Enlist various processes used for manufacturing of Caustic Soda. Explain in detail the mercury cell process for the production of Caustic Soda and its advantages over other processes.

Model Question Paper

QP CODE: **PAGES: 3**

Reg No: _____ **Name: _____**

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SIXTH SEMESTER B. TECH DEGREE EXAMINATION,MONTH & YEAR

Course Code: CHT 306

Max. Marks: 100 Duration: 3 Hours

Course Name: CHEMICAL TECHNOLOGY

PART A

Answer All questions. Each question carries 3 marks.

1. Discuss Settling & Hardening of Cement in brief.
2. Enlist the types of glass and explain any two in brief
3. Discuss in brief: NPK fertilizer.
4. Write down application of Soda ash and Caustic soda
5. List three methods of pulp production
6. State the sources and uses of hydrogen.
7. Discuss the major engineering problems associated with the production of sulphuric acid
8. List the uses of activated carbon.
9. List the food processing methods.
10. List the various steps in the production of absolute alcohol.

(3x10=30 marks)

PART B

Module 1

11.a. With a neat process flow diagram, describe the manufacture of sulfuric acid by DCDA process. (6 marks)

11.b. Discuss Linde's process for manufacture of O2 and N2. Discuss in brief the uses and properties of nitrogen and oxygen gases. (8 marks.)

OR

12. Enlist the methods for the commercial production of Carbon Dioxide. Briefly explain with a neat diagram, the manufacture of carbon dioxide using any method listed.(14marks.)

Module 2

13. Write a short note on Solvay process for the production of Soda ash.List out the major engineering problems associated with it. (14 marks)

OR

14. Explain the manufacturing process of Urea with flow diagram. List the advantages and disadvantages of the process described. (14 marks)

Module 3

15.a. Explain Furnace process for manufacturing of Carbon black with neat flow sheet.

(9 marks)

15.b. Describe in brief about graphite & carbon (5 marks.)

OR

16.a. Explain various types and constituents of Portland cement. (5 marks)

16.b. Explain the manufacturing process of Portland cement with a neat flow diagram.

(9marks)

Module 4

17. a.Explain manufacturing of paper with neat flow sheet. (7marks)

17.b. Explain manufacturing of pulp by using Kraft process. Discuss recovery of chemicals from black liquor. (7 marks)

OR

18.a. What are the different types of glasses and their uses? (5 marks)

18.b. Explain the manufacture of glycerine with a neat diagram, list out the major engineering problems for the production of glycerine. (9 marks)

Module 5

19. Explain any two processes for the manufacture of leather with a neat diagram. (14 marks)

OR

20.a. Explain the manufacturing process for the manufacture of industrial alcohol by fermentation with a neat diagram (7 marks)

20.b. Explain the process for the manufacture of absolute alcohol with a neat diagram

(7marks)

Syllabus

Module 1 (10hrs)

Fuel gases: natural gas, coke oven gas, producer gas, water gas, LPG. Industrial gases: carbon dioxide, hydrogen, nitrogen, oxygen. Sulphur and sulphuric acid: manufacturing of sulphur and sulphuric acid. phosphorus and phosophoric acid: wet process phosphoric acid- electric furnace phosphorus and phosphoric acid, single super phosphate and triple super phosphate.

Module 2 (9hrs.)

Chlor-alkali industries: salt, soda ash, baking soda, caustic soda, chlorine, hydrochloric acid. Nitrogen industries: ammonia, nitric acid, urea, fertilizer industries, ammonium sulphate, ammonium nitrate, nitrolime, MAP, DAP and nitrophosphates, mixed and complex fertilizers.

Module 3 (10hrs.)

Carbon chemicals, carbon black, activated carbon, synthetic graphite, calcium carbide. Surface coating industries: pigments, paints, varnishes, lacquers, industrial coatings. Cement: portland cement, constituents, types, raw materials and manufacturing processes.

Module 4 (8hrs)

Glass: classes of glass, raw materials, methods of manufacture. Ceramics and refractories (general study). Pesticides: DDT, Nicotine, Parathrins, Heptachlor, Endosulfan. Natural products industries: soaps and detergents, glycerine, pulp and paper, wood chemicals, Coal chemicals.

Module 5(8hrs)

General study of food processing, food byproduts, leather, gelatin, adhesives, vegetable oils, animal fats and oils, waxes, sugar, starches and related products, industrial alcohol by fermentation, absolute alcohol, beers, wines and liquors. Pharmaceuticals, biotechnology.

Text Books

1. Austin G.T. (Ed.), Shreve's Chemical Process Industries, McGraw Hill

2. Gopal Rao M. & Sittig M. (Eds.), Dryden's Outlines of Chemical Technology, Affiliated East West Press .

3. Shukla S. D. and G. N. Pandey, "A Text Book of Chemical Technology. Vikas Publishing House, 1986.

Reference Books

1. Chemtech Vol. I – IV, Chemical Engineering Education Development Centre, Indian Institute of Technology, Madras, 1979.

2. Kirk-Othmer Encyclopaedia of Chemical Technology, John Wiley and Sons
3. Ullmann's Encyclopaedia of Industrial Chemistry, John Wiley and Sons

Course Contents and Lecture Schedule

No	Topic	No. of Lectures (Hrs.)
1	**MODULE 1 (10hrs)**	
1.1	Fuel gases: natural gas, coke oven gas, producer gas, water gas, LPG.	2
1.2	Industrial gases: carbon dioxide, hydrogen, nitrogen, oxygen	2
1.3	Sulphur and sulphuric acid: manufacturing of sulphur and sulphuric acid.	2
1.4	Phosphorus and phosophoric acid: wet process phosphoric acid-electric furnace phosphorus and phosphoric acid	2
1.5	Single super phosphate and triple super phosphate.	2
2	**MODULE 2 (9hrs)**	
2.1	Chlor-alkali industries: salt, soda ash, baking soda, caustic soda.	2
2.2	Manufacture of chlorine, hydrochloric acid. Nitrogen industries: ammonia, nitric acid, urea	2
2.3	Fertilizer industries, ammonium sulphate, ammonium nitrate	2
2.4	Nitrolime, MAP, DAP and nitrophosphates.	2
2.5	Mixed and complex fertilizers.	1
3	**MODULE 3(10hrs)**	
3.1	Carbon chemicals, carbon black, activated carbon.	2
3.2	Synthetic graphite, calcium carbide. Surface coating industries: pigments, paints,	2
3.3	Varnishes, lacquers, industrial coatings.	2
3.4	Cement: portland cement constituents, types.	2
3.5	Raw materials and manufacturing processes of Portland cement.	2
4	MODULE 4 (8hrs)	
4.1	Glass: classes of glass, raw materials, methods of manufacture.	1
4.2	Ceramics and refractories (general study). Pesticides: DDT, Nicotine	2
4.3	Parathrins, Heptachlor, Endosulfan	1
4.4	Natural products industries: soaps and detergents, glycerine	2
4.4	Pulp and paper, wood chemicals, Coal chemicals.	2
5	**MODULE 5 (8hrs)**	
5.1	General study of food processing, food byproduts,	1
5.2	Manufacture of leather, gelatin, adhesives.	1
5.3	vegetable oils, animal fats and oils, waxes,	2

5.4	sugar, starches and related products,	1
5.5	industrial alcohol by fermentation, absolute alcohol, beers, wines and liquors.	2
5.6	Pharmaceuticals, biotechnology.	1

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
KTU
Estd.
2014

CHT308	COMPREHENSIVE COURSE WORK	CATEGORY	L	T	P	CREDIT	YEAR OF INTRODUCTION
		PCC	1	0	0	1	2019

Preamble: The course is designed to ensure that the student have firmly grasped the foundational knowledge in Chemical Engineering. It provides an opportunity for the students to demonstrate their knowledge in various Chemical 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 Chemical 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 Chemical Engineering

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1				2						
CO2	3	3				2				3		
CO3	3	1				2				3		
CO4	3	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 Chemical Engineering core courses.

CHT 202 - Chemical Engineering Thermodynamics

CHT 204 –Heat Transfer Operations

CHT 205 - Fluid and Particle Mechanics

CHT 301–Mass Transfer Operations - I

CHT 305–Chemical Reaction Engineering

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) A principal plane is one where the shear stress will be:
A) Maximum
B) Minimum
C) Zero
D) Coverage of principal stress

2) In a differential manometer, the flowing fluid is water and the gauge fluid is mercury. If the manometer reading is 100mm, the differential head in meters is:
A) 13.6
B) 1.36
C)1.47
D)1.26

3) A rectangular open channel carries a flow of $2m^3$/sec/m, what is the value of minimum specific energy?

A) 0.74m
B) 1.11m
C) 1.48m
D) 1.85m

4) A pipe has diameter 0.4m, length 0.1km and coefficient of friction 0.005. What is the length of an equivalent pipe which has diameter 0.2m and coefficient of friction 0.008?

A) 195 m
B) 19.5 m
C)1.95 m
D) 1950 m

5) Which of the following statements are CORRECT?

P. For a rheopectic fluid, the apparent viscosity increases with time under a constant applied shear stress
Q. For a pseudoplastic fluid, the apparent viscosity decreases with time under a constant appliedshear stress
R. For a Bingham plastic, the apparent viscosity increases exponentially with the deformation rate
S. For a dilatant fluid, the apparent viscosity increases with increasing deformation rate

(A) P and Q only
(B) Q and R only
(C) R and S only
(A) P and S only

6) An irreversible gas phase reaction A → 5B is conducted in an isothermal batch reactor at constant pressure in the presence of an inert. The feed contains no B. If the volume of the gas at complete conversion must not exceed three times the initial volume, the minimum mol% of the inert in the feed must be …….

(A) 0
(B) 20
(C) 33
(D) 50

7) The reaction A → B is conducted in a isothermal batch reactor. If the conversion of A increases linearly with holding time, then the order of the reaction is

(A) 0
(B) 1

(C) 1.5
(D) 2

8) Threshold energy in a reaction is equal to the
(A) Activation energy
(B) Normal energy of the reactants
(C) Sum of A & B
(D) Difference between A & B

9) Calculate the loss of heat by radiation from a steel tube of diameter 70 mm and 3 m long at a temperature of 500 K, if the tube is located in a square brick conduit 0.3 m side at 300 K. Emissivity of steel= 0.79, emissivity of brick = 0.93.
(A) 2000 W
(B) 1588 W
(C) 2200 W
(D) 1800 W

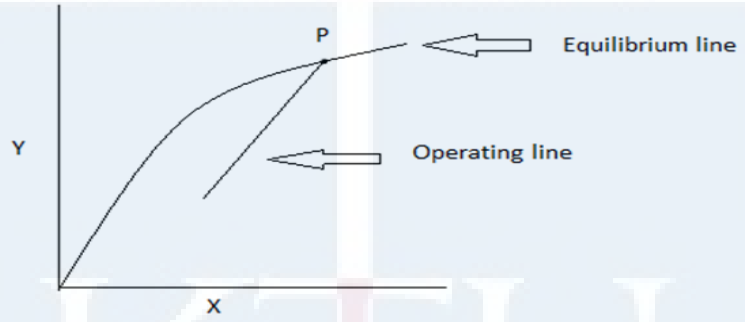
10) In a heat exchanger with steam outside the tubes, a liquid gets heated to 45 ^{o}C, when its flow velocity in the tubes is 2 m/s. If the flow velocity is reduced to 1 m/s, other things remaining the same, the temperature of the exit liquid will be
(A) less than 45 ^{o}C
(B) equal to 45 ^{o}C
(C) greater than 45 ^{o}C
(D) initially decreases and remains constant thereafter

11) In a shell and tube heat exchanger, baffles are provided on the shell side to
(A) prevent the stagnation of shell side fluid
(B) improve heat transfer
(C) provide support for tubes
(D) all of these

12) A counterflow shell and tube heat exchanger is used to heat water with hot exhaust gases. The water (Cp=4180 J/Kg.^{o}C) flows at a rate of 2 kg/s while the exhaust gases (Cp=1030 J/Kg ^{o}C) flows at a rate of 5.2 kg/s. If the heat transfer surface area is 32.5 m^2 and the overall heat transfer coefficient is 200 W/m^{2o}C, what is the NTU for the heat exchanger.
(A) 1.8
(B) 2.4
(C) 4.5
(D) 8.6

13) Prandtl number is the ratio of
(A) Mass diffusivity to thermal diffusivity
(B) Momentum diffusivity to thermal diffusivity
(C) Thermal diffusivity to mass diffusivity
(D) Thermal diffusivity to momentum diffusivity

14) The equilibrium and operating line of a vapour liquid separation process is given below with vapour composition Y on the ordinate and liquid composition X on the abscissa. The driving force at the point P in the diagram is .....



(A) One
(B) Greater than one
(C) Zero
(D) Infinity

15) For very large cooling duties, the cooling preferred is
(A) Induced draft cooling tower
(B) Natural draft cooling tower
(C)Forced draft cooling tower
(D)Atmospheric towers

****

Course Code: CHT 308

Comprehensive Course Work

MODULE 1(Fluid and Particle Mechanics)

Newton's law of viscosity-Physical properties of fluid-Variation of viscosity and density with temperature and pressure-Rheological Classification of fluids-Barometric Equation-Continuous gravity decanter and centrifugal decanter-Principles of Manometer- Simple manometer, inclined tube manometer. Reynold's number – Turbulence-Reynold's stress-Flow in boundary layers-Boundary layer separation and wake formation-Correction for fluid friction, Pump work-Compressible flow-Friction factor and Reynolds number relationship in laminar flow and turbulent flow-Effect of fittings and valves-Hydraulic radius and Equivalent diameter – Fluidization-Fluidized bed and Packed bed-Pressure drop- minimum fluidizing velocity-effect of pressure and temperature on fluidized bed behaviour-Pumps, fan, blower, compressor and its classification-Types of pumps-Centrifugal Pumps-Various losses – NPSH – Cavitation-Specific Speed-Priming.

MODULE 2(Chemical Engineering Thermodynamics)

Steady and unsteady state mass and energy balances including multiphase, multicomponent, reacting and non-reacting systems. Use of tie components; recycle, bypass and purge calculations; Gibb's phase rule and degree of freedom analysis. First and Second laws of thermodynamics. Applications of first law to close and open systems. Second law and Entropy. Thermodynamic properties of pure substances: Equation of State and residual properties, properties of mixtures: partial molar properties, fugacity, excess properties and activity coefficients; phase equilibria: predicting VLE of systems; chemical reaction equilibrium.

MODULE 3 (Heat Transfer Operations)

Conduction heat transfer- Fourier heat conduction equation, conduction through plane, cylindrical and spherical wall, conduction through composite slab - multi-layered plane, cylindrical and spherical shells, lumped capacity analysis, Forced Convection - General methods for estimation of forced convection heat transfer coefficient for flow through tubes and flow over flat plates, Natural Convection-natural convection from vertical and horizontal surfaces under laminar and turbulent conditions for plates and cylinders under constant heat flux and wall temperature conditions, Heat transfer by radiation-radiation between large parallel gray planes, concentric cylinders and spheres, radiation between a small gray body and a large gray enclosure, Heat exchangers - Concept of overall heat transfer coefficient-determination of overall heat transfer coefficient with and without fouling, concept of logarithmic mean temperature difference and its correction factor, NTU method, determination of area, length,number of tubes required for a given duty in different configurations using LMTD and NTU method of analysis.

Evaporation- capacity and economy of evaporators, material and energy balances for single effect evaporator and the calculations on single effect evaporator.

MODULE 4 (Mass Transfer Operations – I)

Molecular diffusion-mass fluxes J_A and N_A - Fick's law, steady state diffusion of A through stagnant B and equimolar counter diffusion, Mass transfer coefficients, dimensionless groups, theories of mass transfer, interphase mass transfer, Gas-Liquid contacting equipments for mass transfer operations, factors affecting column performance, Gas absorption, Material balance in counter current and concurrent absorption, multistage operation, number of plates, tray efficiency, design of packed columns, transfer units, adsorption, adsorption isotherms, rate of adsorption, humidification, Lewis relation, types of cooling towers, drying, moisture content, rate of drying, batch and continuous drying.

MODULE 5 (Chemical Reaction Engineering)

Theories of reaction rates, kinetics of homogeneous reaction, interpretation of kinetic data, reactions in ideal reactors, single and multiple reactions, non-isothermal reactors, Heat effects: adiabatic and non -adiabatic operations, Non-ideal reactors, residence time distribution, RTD in ideal reactors, single parameter model reactions.

****

CHL 332	MASS TRANSFER OPERATIONS LAB	CATEGORY	L	T	P	CREDIT
		PCC	0	0	3	2

Preamble: This course familiarizes the student with various mass transfer operations by doing experiments. This course helps the students to operate and understand the working of mass transfer equipments.

Prerequisite: Theoretical knowledge on Mass Transfer Operations.

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

CO 1	Apply the fundamental knowledge of mass transfer in related practical problems
CO 2	Analyse different mass transfer operations
CO 3	Experiment with various mass transfer equipments
CO 4	Examine separation processes such as simple distillation, steam distillation etc. to estimate the composition in products
CO 5	Plan and conduct the experiments and present the experimental data meaningfully
CO 6	Develop teamwork 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											
CO 2	3	3			2							
CO 3	3											
CO 4	3	3										
CO 5										3		
CO 6									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 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.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Plot the percentage actual recovery against solvent to feed ratio for single stage leaching.
2. Draw the binodal solubility curve for benzene-water-acetic acid system.
3. Determine the Freundlich constants for adsorption of acetic acid on activated carbon.

Course Outcome 2 (CO2)

1. Find the actual and theoretical recovery for simple leaching with varying number of stages.
2. Draw tie line in binodal solubility curve of benzene-water- acetic acid system.
3. Verify the Rayleigh equation for the simple distillation experiment.

Course Outcome 3(CO3):

1. Find the stage efficiency for the cross current leaching experiment.
2. Find the mass transfer coeffient for wetted wall column experiment.
3. Determine the time of drying using the batch drying set up.

Course Outcome 4 (CO4):

1. Compare vaporisation and thermal efficiency for steam distillation of turpentine.
2. Verify material balance equation for simple distillation of methanol-water mixture.
3.Draw the binodal solubility curve for benzene-water-acetic acid system.

Course Outcome 5 (CO5):

1. Find the overall stage efficiency of continuous counter current leaching unit.
2. Compare the recovery between simple leaching with varying number of stages and varying solvent to feed ratio.

Course Outcome 6 (CO6):

1. Demonstrate the working of diffusivity measurement apparatus.
2. Explain the working of mass transfer coefficient in surface evaporation equipment.
3. Demonstrate the working of atmospheric batch drying unit.

LIST OF EXPERIMENTS (A minimum of 8 experiments has to be conducted)

1. Diffusion coefficient measurement
2. Simple Distillation
3. Steam Distillation
4. Surface Evaporation-free convection mass transfer
5. Liquid extraction- Determination of Ternary liquid-liquid equilibria
6. Simple leaching-varying solvent to feed ratio
7. Simple leaching- varying number of stages
8. Cross current leaching
9. Counter current leaching
10. Adsorption Isotherm
11. Atmospheric batch drying
12. Wetted wall column-measurement of mass transfer coefficient
13. Any other experiments related to mass transfer operations applicable in Chemical Engineering.

Reference Books

1. Robert E Treybal, Mass Transfer Operations, McGraw Hill.
2. K V Narayanan and B Lakshmikutty, Mass Transfer: Theory and Applications, CBS Publishers and Distributors Pvt. Ltd.

CHL 334	CHEMICAL REACTION ENGINEERING LAB	CATEGORY	L	T	P	CREDIT
		PCC	0	0	3	2

Preamble: This course help the students to understand the principles of kinetics of Chemical Reactions through experimentation. This practical course familiarizes the students the principle and working of various chemical reactors.

Prerequisite: Theoretical knowledge of Chemical Reaction Engineering.

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

CO 1	Deduce kinetic equation of homogenous chemical reactions and analyse the factors effecting the reactions
CO 2	Analyse the effect of temperature in chemical equation and validation of Arrhenius law.
CO 3	Determine the kinetics of reaction in ideal reactors- Batch Reactor, PFR and MFR
CO 4	Analyse the principle, working, selection of Chemical Reactors and arriving at designing ideal reactors.
CO 5	Account for non ideality in chemical reactors by calculating residence time distribution
CO 6	Interpret and present the experimental data meaningfully and develop teamwork 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								3			
CO 2	3	3										
CO 3	3	3	2									
CO 4	3								3			3
CO 5	3								3	3		
CO 6	3								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 : 15Marks
(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.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Discuss the effect of catalyst on activation energy.
2. What is Arrhenius theory for temperature dependency of reaction rate

Course Outcome 2 (CO2)

1. Explain integral and differential methods for rate analysis
2. Define equivalent weight. what is its relation to valency and atomic weight.

Course Outcome 3(CO3):

1. Compare the performance of MFRs for first and second order reactions.
2. What are essential characteristics of a PFR

Course Outcome 4 (CO4):

1. Explain how the conversion in a reactor can be obtained from RTD studies
2. What are the reasons behind non-ideal behaviour of reactors

Course Outcome 5 (CO5):

1. Explain the effect of recycle ratio in a autocatalytic reaction.
2. What is the effect of multiple PFRs in series.

Course Outcome 6 (CO6):

1. How do we calculate the optimum recycle ratio a recycle reactor? What is its significance?
2. Write the advantages and disadvantages of conducting a laboratory kinetic study in a batch reactor over other reactor configurations

LIST OF EXPERIMENTS (Minimum of 8 experiments are mandatory)

1. Isothermal Batch Reactor
2. Isothermal Plug Flow Reactor
3. Isothermal CSTR
4. Packed Bed Reactor
5. RTD Studies in a Packed Bed Reactor
6. RTD Studies in CSTR
7. RTD Studies in PFR
8. Combined Flow Reactor
9. UV Photo Reactor
10. Determination of activation energy
11. Kinetics of reactions
12. Recycle Reactor
13. Electrochemical Reactor
14. Any other experiments related to chemical reaction engineering applicable in chemical engineering field.

Reference Books

1. H, Scott Fogler, “Elements of Chemical Reaction Engineering”, Prentice Hall of India.
2. K.G Denbigh& J.C.R Turner, „Chemical Reactor Theory- An Introduction‟, 3rd Ed., Cambridge University Press
3. Levenspiel Octave , “Chemical Reaction Engineering”, John Wiley & Son‟s.
4. Ronald W. Missen, Charles A. Mims, Bradley A. Saville, „Introduction to Chemical Reaction Engineering and Kinetics‟, John Wiley & Sons
5. Smith J.M, “Chemical Engineering Kinetics,” McGraw Hill.

SEMESTER VI

PROGRAM ELECTIVE I

CHT 312	BIOCHEMICAL ENGINEERING	CATEGORY	L	T	P	CREDIT
		PEC	2	1	0	3

Preamble: Biochemical engineering, also known as bioprocess engineering amalgamates the facts from both chemical engineering and biological engineering. It mainly deals with the design, construction, and advancement of unit processes that involve biological organisms or organic molecules. This subject has various applications in the areas of biofuels, pharmaceuticals, agriculture, food sciences, biotechnology and water treatment processes.

This course would enable students to gain a basic knowledge on application of the biological processes to make useful chemicals which can be utilized in the aforesaid areas.

Prerequisite: Nil

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

CO1	Describe different types of cells, classification of kingdom Protista and potential of chemicals of life
CO2	Interpret kinetics of enzyme catalyzed reactions
CO3	Describe Immobilized enzyme technology. Apply basic knowledge of energy and material balances for understanding the metabolic pathways within the cell
CO4	Apply heat and mass transfer principles in bioreactors and bioprocess
CO5	Describe design and operation of a fermentation process and use of sensors

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										
CO 3	3					2				2		
CO 4	3					3						
CO 5	3					3						

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	10
Understand	20	20	30
Apply	20	20	60
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. Compare eukaryotic and prokaryotic cells in terms of internal structure and functions
2. With the help of chemical structure, comment on the functional importance of cellulose, phospholipids, and amino acids

Course Outcome 2 (CO2)

1) The following initial rate data were obtained as a function of initial substrate concentration. Evaluate the Michaelis- Menten kinetic parameters by employing the Eadie-Hofstee plot.

Substrate Concentration (mol/L).	Initial reaction rate (mol/L s)
0.0031	0.11
0.005	0.15
0.0063	0.14
0.009	0.17
0.01	0.21

2) Explain competitive and uncompetitive inhibitions in enzymatic reactions with suitable plots

Course Outcome 3(CO3):

1. Give different methods of immobilization of enzymes
2. Compare the number of ATP molecules produced during glycolysis in TCA cycle and electron transport chain.

Course Outcome 4 (CO4):

1. Explain the oxygen transfer in fermentation process with the help of mass transfer coefficient

2. Describe the working of airlift and fluidized bed bioreactors

Course Outcome 5 (CO5):

1. Explain the medium formulation in a fermentation process

2. Describe on line sensors with suitable example

Model Question paper

QP CODE: **PAGES:2**

Reg No:_____

Name :_____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
SIXTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR
Course Code: CHT 312 BIOCHEMICAL ENGINEERING

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

(2019-Scheme)

PART A

(Answer all questions, each question carries 3 marks)

1. Write about the sugar which is used in genetic material
2. Write examples of primary metabolites and secondary metabolites?
3. Explain Eadie Hofstee plot
4. Explain the substrate activation.
5. List out six enzymes of industrial importance?
6. What are the role of ATP and ADP in metabolic reactions
7. What is Damkohler number?
8. Explain three operational stages in a bioprocess
9. Explain the working of an electrostatic precipitator.
10. What are the sources and effects of noise pollution?

PART B

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

MODULE-I

11. a) Draw a neat sketch of a prokaryotic cell and explain its structure (5)

    b) Explain the functions of different eukaryotic cell organelles (9)

12. a) Explain differential centrifugation method of cell fractionation (9)

    b) Describe five different classification of lipids . (5)

MODULE-II

13. a) Explain reversible modulation in the biosynthesis of L- isoleucine (5)

    b) Derive Michaelis Menton Equation for single substrate system (9)

14. a) Derive the kinetic expression for a non-competitive inhibition (7)

    b) Describe enzyme specificity hypothesis (7)

MODULE-III

15. a) Explain in the physical methods of enzyme immobilization (7)

    b) Describe the pentose phosphate cycle with a neat diagram (7)

16. a) With a neat figure, explain the growth cycle in a microbial batch cultivation (7)

    b) Explain passive and active transport in cell membranes (7)

MODULE-IV

17. a) Describe with a diagram the continuous heat sterilization (7)

    b) Describe the rate of metabolic oxygen utilization in a fermentation process (7)

18. a) Explain in the working of a Photobioreactors (6)

    (b) List out the steps involved in the transfer of oxygen from a gas bubble to reaction site inside a cell (8)

MODULE-V

19. a) What are the advantages and disadvantages of offline sensors? (7)

    b) What are the characteristics of gas analysis sensors? (7)

20. Describe the design and operation of a typical aseptic, aerobic fermentation process (14)

Syllabus

Module 1 (6 Hours)

Micro Biology, Cell theory, Structure of cells, Cell fractionation, protist kingdom and their distinguishing characteristics . Chemicals of life: repetitive and non repetitive bio polymers - lipids, sugars and polysaccharides, amino acids and proteins. Protein structure nucleotides RNA and DNA

Module 2 (7 Hours)

Kinetics of Enzyme catalyzed reactions: simple enzyme kinetics with one or two substrates, Michaelis - Menten Kinetics, Evaluation of parameters in Michaelis – Menten equation, Substrate concentration dependence of enzyme catalysed reactions: substrate activation and inhibition, Modulation and regulation of enzyme activity – competitive and uncompetitive inhibition. Enzyme specificity and enzyme specificity hypotheses

Module 3 (7 Hours)

Enzymes of industrial importance. Immobilized enzyme technology: enzyme immobilization, medical and analytical applications of immobilized enzymes. Batch cultivation - growth cycle (lag, exponential, stationary and death phase)
Metabolic pathways and energetics of the cell: Metabolic reaction coupling : ATP, ADP and NAD. Oxidation and reduction- Coupling via NAD. Embden-Meyerhof pathway (EMP), Pentose phosphate cycle , Respiration - TCA cycle. Transport across cell membranes - passive transport, active transport and facilitated diffusion.

Module 4 (7 Hours)

Transport phenomena in Bio process system-Gas-liquid mass transfer in cellular system - basic mass transfer and concepts - rates of metabolic oxygen utilization – determination of oxygen transfer rates-mass transfer across free falling or raising bubble and free surface with or without agitation in heat transfer. Biochemical reactors-specifications Continuous stirred tank bioreactor, bubble column bioreactor, Airlift bioreactors, Fluidized bed bioreactors, Packed bed bioreactors, and photo bioreactors. Types of reactors for sterilization

Module 5 (8 Hours)

Fermentation technology, medium formulation, design and operation of a typical aseptic, aerobic fermentation process. Different configurations for fermentors. Concept of biosensors. Physical and chemical sensors, gas analysis sensors, On-line sensors and offline sensors.for cell properties

Text Books

1. James E. Bailey and David F. Ollis., “Bio-chemical Engineering Fundamentals”. Mc Graw Hill International Editions.
2. D G Rao., “Introduction to Biochemical Engineering”, Tata Mc Graw Hill.

3. Michael L Shuler and Frikret Khargi., "Bioprocess Engineering Basic Concepts" PHI Publications.

Reference Books

1. Biochemical Engineering by H. W.Blanch & D.S. Clark, Marcel Dekker, Inc., 1997.
2. Bioprocess Engineering principles Paulin M Doran ISBN-978-0-12-220851-5

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Module I (6 hours)**	
1.1	Structure of cells, prokaryotic and eukaryotic cells,	1
1.2	Cell fractionation	1
1.3	Protist kingdom and their distinguishing characteristics	1
1.4	Classification of microorganisms belonging to the kingdom of protists	1
1.5	Chemicals of life: repetitive and non repetitive bio polymers Lipids, Sugars and polysaccharides	1
1.6	Amino acids and proteins, Protein structure, Nucleotides RNA and DNA	1
2	**Module II (7 hours)**	
2.1	Enzyme substrate complex and enzyme action simple enzyme kinetics with one or two substrates	1
2.2	Derivation of Michaelis - Menten Kinetics, evaluation of parameters in M M kinetics	1
2.3	Description of Substrate activation and inhibition	1
2.4	Modulation and regulation of enzyme activity- mechanism of reversible enzyme modulation	1
2.5	Derivation of competitive inhibition	1
2.6	Derivation of uncompetitive inhibition	1
2.7	Different factors affecting enzyme activity, Enzyme specificity and enzyme specificity hypotheses	1
3	**Module III (7 hours)**	
3.1	Important enzymes of industrial importance, Different methods for Enzyme immobilization	1
3.2	Medical and analytical applications of immobilized enzymes	1
3.3	Growth cycle in batch cultivation -(lag, exponential, stationary and death phase)	1
3.4	Metabolic reaction coupling : ATP, ADP and NAD	1
3.5	Oxidation and reduction- Coupling via NAD	1
3.6	Embden-Meyerhof pathway (EMP), Pentose phosphate cycle, Respiration - TCA cycle	1
3.7	Transport across cell membranes - passive transport, active transport and facilitated diffusion.	1
4	**Module IV (7 hours)**	

4.1	Gas-liquid mass transfer in cellular system – basic mass transfer and concepts, rates of metabolic oxygen utilization	1
4.2	Determination of oxygen transfer rates-mass transfer across free falling or raising bubble and free surface with or without agitation in heat transfer	1
4.3	Specifications and operational stages in a bioreactor, Continuous stirred tank bioreactor, bubble column bioreactor	2
4.4	Airlift bioreactors, Fluidized bed bioreactors,	1
4.5	Packed bed bioreactors, and photo bioreactors	1
4.6	Types of reactors for batch sterilization, Types of reactors for continuous sterilization	1
5	**Module V (8 hours)**	
5.1	Medium formulation in fermentation	1
5.2	Design and operation of a typical aseptic, aerobic fermentation process.	2
5.3	Alternate bioreactor configurations	1
5.4	Sensors of the physical environment, gas analysis sensors	1
5.5	Medium chemical sensors	1
5.6	On-line sensors for cell properties	1
5.7	Off-line sensors for analytical methods	1

CHT322	ENERGY ENGINEERING	CATEGORY	L	T	P	CREDIT
		PEC	2	1	0	3

Preamble: After studying this course students will be aware of different form of energy and methods for harnessing different energy resources. They also understand the importance of energy conservation and the different methods employed for energy conservation in industry and day to day life.

Prerequisite: NIL

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

CO 1	Identify different sources of energy , analyse the energy scenario and understand different conventional energy production systems
CO 2	Explain the concepts of solar and ocean energy conversion
CO 3	Explain the Wind and biomass energy conversion technologies
CO 4	Explain the working and types of fuel cells and MHD systems
CO 5	Explain the concepts of energy conservation and energy audit and apply the knowledge in process plants and daily life

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	2					2
CO 2												
CO 3	2		3									
CO 4			3									
CO 5			3			3	2	2			2	

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	10
Understand	20	20	20
Apply	10	10	60
Analyse	10	10	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):

1. Differentiate between renewable and non renewable energy resources
2. Analyse the energy situation in India and give your suggestions for a better energy independence
3. Classify the different energy resources

Course Outcome 2 (CO2)

1. Discuss different Solar energy conversion technologies
2. Analyse the working of Solar PV system and suggest the methods to improve the efficiency
3. Discuss the different ocean energy conversion technologies and comment on their future

Course Outcome 3(CO3):

1. Analyse the wind energy harnessing status in India
2. Discuss different wind energy conversion technologies
3. Analyse the process of biomass conversion technologies

Course Outcome 4 (CO4):

1. Explain the working of a fuel cell and discuss the classification
2. Explain the working of MHD systems

Course Outcome 5 (CO5):

1. discuss the energy conservation methods employed in chemical process plants
2. Analyse the concept of pinch Technology
3. Discuss the use of cogeneration as a energy conservation tool

Model Question paper

QP CODE: **PAGES:2**
Reg No:_____
Name :_____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
SIXTH SEMESTER B.TECH DEGREE EXAMINATION,
MONTH & YEAR
Course Code: CHT 322 ENERGY ENGINEERING
Max. Marks: 100 **Duration: 3 Hours**

(2019-Scheme)
PART A
(Answer all questions, each question carries 3 marks)

1.Write a note on classification of energy resources
2.Explain the principle of fluidised bed combustion
3.Write the principle and working of solar pond
4.Discuss the principle of tidal energy conversion
5.Explain the steps in the anaerobic digestion of biomass
6.Discuss the wind energy situation in India
7.What is a fuel cell? Explain the principle and working
8.Explain the methods to harness geothermal energy
9.Distillation is an energy intensive operation. Give the energy conservation measures in a distillation column
10. Explain the concept of Pinch Technology (10x3=30 marks)

PART B

11. Discuss the present Indian energy scenario and give your suggestions for a better energy sustainability (14 marks)

OR

12. With a neat lay out explain the working of thermal power plant. List out the merits and demerits (14 marks)

OR

13. a) Explain the working of different solar collectors (7 marks)

b) Solar PV cells and its future. Comment (7 marks)

14. With a neat diagram explain the working of open and closed cycle ocean thermal energy conversion systems (14 marks)

OR

15. Explain different wind energy conversion systems (14 marks)

16. Thermo chemical routes of biomass energy conversion systems: Explain the principle and working (14 marks)

OR

17. Discuss the classification of fuel cell. Explain the working any two fuel cells (14 marks)

18. With a neat diagram explain the working MHD systems (14 marks)

19. What is energy audit? Discuss different types and objectives (14 marks)

OR

20. Write in detail about the energy conservation measures in a chemical process plants (14 marks)

Syllabus

Module 1 (6 hours)

Energy, general classification of energy, world energy resources and energy consumption, Indian energy resources and energy consumption, energy Crisis, energy alternatives, thermal, hydel and nuclear power plants, efficiency, merits and demerits of the above power plants, fluidized bed combustion, combined cycle power plants

Module 2 (7 hours)

Solar energy, solar thermal systems, flat plate collectors, focusing collectors, solar water heating, solar cooling, solar distillation, solar refrigeration, solar dryers, solar pond, solar thermal power generation, solar energy application in India, , photo voltaic systems , energy plantations.

Ocean wave energy conversion, ocean thermal energy conversion, tidal energy conversion,

Module 3 (7 hours)

Wind energy, types of windmills, types of wind rotors, Darrieus rotor and Savanius rotor, wind electric power generation, wind power in India, economics of wind farm

Biomass energy resources, thermochemical and biochemical methods of biomass conversion, combustion, gasification, pyrolysis, fermentation, anaerobic digestion

Module 4 (7 hours)

Fuel cells, alkaline fuel cell, phosphoric acid fuel cell, molten carbonate fuel cell, solid oxide fuel cell, solid polymer electrolyte fuel cell, Basic concepts of Microbial Fuel Cell
Magneto hydro dynamics: open cycle and closed cycle systems,geothermal energy.

Module 5 (8 hours)

Energy audit and Energy conservation in chemical process plants, energy saving in heat exchangers, distillation columns, furnaces and boilers, steam economy in chemical plants, energy conservation in petroleum, fertilizer and steel industry, cogeneration (CHP), pinch technology, recycling for energy saving, electrical energy conservation in chemical Process plants, environmental aspects of energy use.

Text Books

1. Rao S. &Parulekar B.B., Energy Technology, Khanna Publishers.
2. Bansal N.K., Kleeman M. &Meliss M., Renewable Energy Sources & Conversion Tech., Tata McGraw Hill.
3. Goldmberg J., Johansson, Reddy A.K.N. & Williams R.H., Energy for a Sustainable World, John Wiley

Reference Books

1. Sukhatme S.P., Solar Energy, Tata McGraw Hill
2. Mittal K.M., Non-Conventional Energy Systems, Wheeler Publications
3. Venkataswarlu D.I, Chemical Technology, S. Chand
4. Pandey G.N., A Text Book on Energy System and Engineering, Vikas Publishing.
5. Rai G.D., Non-Conventional Energy Sources, Khanna Publishers.
6. S.S.Thipse, Energy conservation and management, Narosa Publishing House

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Energy classification, energy scenario and types of power plants (6 hours)**	
1.1	general classification of energy,	1
1.2	world energy resources and energy consumption, Indian energy resources and energy consumption	1
1.3	energy Crisis, energy alternatives,	1
1.4	thermal, hydel and nuclear power plants	1
1.5	efficiency , merits and demerits of the above power plants, fluidized bed combustion	1
1.6	combined cycle power plants	1

2	**Solar energy and ocean energy (7 hours)**	
2.1	solar thermal systems, flat plate collectors, focusing collectors	1
2.2	solar water heating, solar cooling, solar distillation	1
2.3	solar refrigeration, solar dryers, solar pond	1
2.4	solar thermal power generation, solar energy application in India	1
2.5	photo voltaic systems , energy plantations	1
2.6	Ocean wave energy conversion, ocean thermal energy conversion, ,	1
2.7	tidal energy conversion	1
3	**Wind Energy and Biomass Energy (7 hours)**	
3.1	Wind energy, types of windmills	1
3.2	Types of wind rotors, Darrieus rotor and Savanius rotor,	1
3.3	Wind electric power generation, wind power in India	1
3.4	, economics of wind farm	1
3.5	Biomass energy resources,	1
3.6	Thermo-chemical methods of biomass conversion, combustion, gasification, pyrolysis	1
3.7	Biochemical methods of biomass conversion: fermentation, anaerobic digestion	1
4	**Fuel cells, MHD and geothermal energy (7 hours)**	
4.1	Fuel cells, alkaline fuel cell,	1
4.2	Phosphoric acid fuel cell, Molten carbonate fuel cell	1
4.3	Solid oxide fuel cell, solid polymer electrolyte fuel cell, Basic concepts of Microbial Fuel Cell	1
4.4	Magneto hydro dynamics: introduction	1
4.5	Open cycle and closed cycle systems,	1
4.6	Geothermal energy	1
4.7	Methods for harnessing geothermal energy	1
5	**Energy audit and Energy conservation (8 hours)**	
5.1	Energy audit and Energy conservation in chemical process plants,	1
5.2	Energy saving in heat exchangers, distillation columns, furnaces and boilers	1
5.3	steam economy in chemical plants,	1
5.4	energy conservation in petroleum, fertilizer and steel industry,	1
5.5	cogeneration (CHP),	1
5.6	pinch technology	1
5.7	recycling for energy saving	1
5.8	Electrical energy conservation in chemical Process plants, environmental aspects of energy use.	1

CHT332	NUMERICAL METHODS FOR PROCESS ENGINEERS	CATEGORY	L	T	P	CREDIT
		PEC	2	1	0	3

Preamble: Numerical Methods use computers to solve problems by step-wise, repeated and iterative solution methods, which would otherwise be tedious or unsolvable by hand-calculations. This course is designed to give an overview of numerical methods of interest to scientists and engineers. The course aims at giving adequate exposure to methods for numerically solving algebraic and transcendental equations, system of linear and non-linear equations, polynomial interpolation, differential and partial differential equations.

Prerequisite:Nil

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

CO 1	Identify the errors, source of error and its effect on any numerical computations
CO 2	Solve polynomial and transcendental equation using an appropriate numerical method.
CO 3	Solve linear and non-linear algebraic system of equations using an appropriate numerical method.
CO 4	Apply different numerical methods for interpolation, differentiation and integration of functions and analyze errors.
CO 5	Solve ordinary differential equations by different numerical methods.
CO 6	Solve elliptic, parabolic, and hyperbolic partial differential equations using finite difference methods.

Mapping of course outcomes with program outcomes

	PO1	PO2	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			3							2
CO 3	3	3										2
CO 4	3	3										2
CO 5	3	3										2
CO 6	3	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): Identify the errors, source of error and its effect on any numerical computations**.**

- If $z = (xy^3)/8$, find the percentage error in 'z' when $x = 3.14 \pm 0.0016$ and $y = 4.5 \pm 0.05$

Course Outcome 2 (CO2): Solve polynomial and transcendental equation using an appropriate numerical method.

- Air at 25°C and 1 atm flows through a 4 mm diameter tube with an average velocity of 50 m/s. The roughness is ε = 0.0015 mm. Use Newton – Raphson method to determine the friction factor using the Colebrook equation.

$$\frac{1}{f} = -2.0\ log\left(\frac{\varepsilon/D}{3.7} + \frac{2.51}{R_e\sqrt{f}}\right)$$

Determine the pressure drop in a 1 m section of the tube using the relation

$$\Delta P = \frac{fL\bar{V}\rho}{2D}$$

Density of the air at 25°C and 1 atm is 1.23 kg/m^3 and the viscosity is 1.79 X 10^{-5} kg/ms.

Course Outcome 3(CO3): Solve linear and non-linear algebraic system of equations using an appropriate numerical method**.**

- Apply Gauss – Jordan method to solve the following equations

$$x + y + z = 9$$
$$2x - 3y + 4z = 13$$
$$3x + 4y + 5z = 40$$

Course Outcome 4 (CO4): Apply different numerical methods for interpolation, differentiation and integration of functions and analyze errors**.**

- The following data gives the melting point of an alloy of lead and zinc, where t is the temperature in ^{0}C and P is the percentage of lead in the alloy:

p	40	50	60	70	80	90
t	184	204	226	250	276	304

Using Newton's interpolation formula, find the melting point of the alloy containing 84 percent of lead.

- In an attempt to understand the mechanism of the depolarization process in a fuel cell, an electro-kinetic model for mixed oxygen-methanol current on platinum was developed in the laboratory at FAMU. A very simplified model of the reaction developed suggests a functional relation in an integral form. To find the time required for 50% of the oxygen to be consumed, the time, *T(s)*is given by

$$T = -\int_{1.22*10^{-6}}^{0.61*10^{-6}} \left|\frac{6.73x + 4.3025 * 10^{-7}}{2.316 * 10^{-11}x}\right| dx$$

Use Simpson's 1/3 rule with n = 8 to find the time required for 50 % of the oxygen to be consumed

Course Outcome 5 (CO5): Solve ordinary differential equations by different numerical methods**.**

- The concentration of salt x in a homemade soap maker is given as a function of time by

$$\frac{dx}{dt} = 37.5 - 3.5x$$

At the initial time, t = 0, the salt concentration in the tank is 50 g/L. Determine the salt concentration after 3 minutes by Runge-Kutta 4th order method with a step size of, h = 0.75 min

Course Outcome 6 (CO6): Solve elliptic, parabolic, and hyperbolic partial differential equations using finite difference methods.

- Solve the equation below subject to the initial condition u(x, y, 0) = sin 2πx sin 2πy, 0 ≤ x, y ≤ 1, and the conditions u(x, y, t) = 0, t > 0 on the boundaries.

$$\frac{\partial u}{\partial t} = \frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2}$$

Obtain the solution up to three time level with h = 1/3 and α = 1/8

Model Question Paper

QP CODE: **PAGES: 4**

Reg No.:_____ Name:_____

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

Course Code: CHT332

Course Name: NUMERICAL METHODS FOR PROCESS ENGINEERS

Max. Marks: 100 Duration: 3 Hours

PART A

Answer All the Questions (10 x 3 = 30) **Marks**

1 List the possible errors that may encounter in numerical calculations? 3

2 The specific volume of n-butane at 500 K and 18 atm using the Redlich–Kwong equation of state is given as $18v^3 - 41v^2 + 9.4v - 1 = 0$. Obtain the solution to find out the volume using Newton-Raphson method. 3

3 Using Jacobi's method to solve, $10x + y + z = 12,\ \ 2x + 10y + z = 13,\ \ x + y + 5z = 7$. 3

4 Find the numerically larger eigen value of the matrix $A=\begin{bmatrix} 3 & -5 \\ -2 & 4 \end{bmatrix}$ by Power method. 3

5 Derive Newton's forward interpolating polynomial. 3

6 Surface tension of water is measured at various temperatures. It decreases with temperature as follows: 3

T (^{0}C)	20	30	40	50

γ(mN m^{-1})	72.8	71.2	69.6	67.9

Estimate the surface tension at 37^{0}C using Lagrangian interpolation formula.

7 Obtain $\left[\frac{d^2y}{dx^2}\right]$ using Newton's backward difference formula. 3

8 Use Simpsons 1/3rd formula to numerically integrate $\int_0^2 e^{x^2}\,dx$. 3

9 Using simple Euler's method, $\frac{dy}{dx} = \frac{y-x}{y+x}$, *with* $y(0)=1$, *and find* $x=0.1$. 3

10 Show that central difference approximation of derivatives have 2nd order accuracy. 3

PART B

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

Module I

11 a) A spherical particle is falling through a liquid such that its true Reynolds number is 700. However, due to imprecise estimates of the physical properties, the value of Reynolds number is reported to be 664.8 only. The drag coefficient depends on Reynolds number as per the equation: $C_D = \left(\frac{12}{N_{Re}}\right)[1 + 0.15(N_{Re})^{0.687}]$ where C_D is the drag coefficient and N_{Re} is Reynolds number. Determine the percentage relative error in the value of the drag coefficient if the inaccurate value of Reynolds number is used. 8

b) Find the real root of the equation $3x - \sqrt{(1+\sin x)} = 0$, using bisection method in four steps. 6

12 a) Air at 25 oC and 1 atm flows through a 4mm diameter tube with an average velocity of 50 m/s. the roughness is ε=0.0015 mm. Calculate the friction factor using Newton's Raphson method

$$\frac{1}{\sqrt{f}} = -2\log\left(\frac{\varepsilon/D}{3.7} + \frac{2.51}{Re\sqrt{f}}\right)$$

Determine the pressure drop in a 1m section of the tube using the relation 8

$$\Delta P = \frac{fL\tilde{V}^2\rho}{2D}$$

Density of air at 25^{o}C and 1 atm is 1.23 kg/m^3 and viscosity is 1.79x10^{-5} kg/ms

b) Find all the roots of the equation $x^3 - 6x^2 + 11x - 6 = 0$, by Graeff's root squaring method with four squaring. 6

Module II

13 a) Find the inverse of the coefficient matrix of the system by Gauss-Jordan method.

$$\begin{bmatrix} 1 & 1 & 1 \\ 4 & 3 & -1 \\ 3 & 5 & 3 \end{bmatrix}\begin{bmatrix} x1 \\ x2 \\ x3 \end{bmatrix} = \begin{bmatrix} 1 \\ 6 \\ 4 \end{bmatrix}$$ 6

b) Two separators are used in a process plant to treat a feed (F) containing 100 kg of a mixture of three chemicals A, B and C. In the first separator, 80 % of A is removed and, in the second separator, 83 % of B is removed. The final outlet 8

contains a C rich stream. The compositions of the streams shown in the figure are given below:

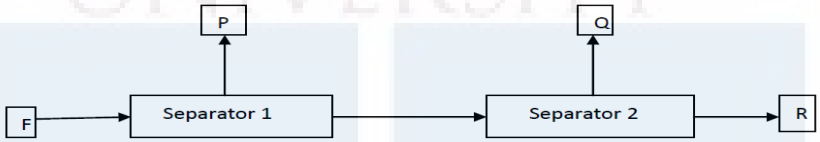
Stream F: $A = 50\%; B = 30\%; C = 20\%$

Stream P: $A = 80\%; B = 10\%; C = 10\%$

Stream Q: $A = 2\%; B = 83\%; C = 15\%$

Stream R: $A = 6\%; B = 12\%; C = 82\%$.

Determine the quantity of mixture in each of the streams P, Q and R using Gauss elimination method.



14 a) Using Gauss-Seidel method, find the solution of the following system of linear equations correct to three decimal places. 7

$$10x + y - 2z = 7.74$$
$$x + 12y + z = 39.66$$
$$3x + 4y + 15z = 54.8$$

b) Find the real root of the equations 7

$$x^2 - y^2 = 4$$
$$x^2 + y^2 = 16$$

Module III

15 a) Using Divided difference formula find the missing value from the table 7

x	1	2	4	5	6
y	14	15	5	.....	9

b) Use Stirling's formula to evaluate y_{28} given that 7

$y_{20} = 49225, y_{25} = 48316, y_{30} = 47236, y_{35} = 45926, y_{40} = 44306.$

16 a) If y_1=4, y_3=12, y_4=19 and y_x=7, determine x using Lagrange inverse interpolation. 7

b) Use Newton's divided difference formula to find f(x) from the following data. 7

x	0	2	3	4	6	7
f(x)	0	8	0	-72	0	1008

Module IV

17 a) Given that 7

x	1.0	1.1	1.2	1.3	1.4	1.5	1.6
y	7.989	8.403	8.781	9.129	9.451	9.750	10.031

find $\frac{dy}{dx}$ *and* $\frac{d^2y}{dx^2}$ at x=1.1

b) Compute the value of π from the formula $\frac{\pi}{4}=\int_0^1 \frac{dx}{1+x^2}$ using trapezoidal rule with 10 sub intervals. 7

18 a) The velocity v (km/min) of a moped which starts from rest is given at fixed intervals of time t (min) as follows: 7

t	2	4	6	8	10	12	14	16	18	20
v	10	18	25	29	32	20	11	5	2	0

Estimate approximately, the distance covered in 20 minutes using Trapezoidal formula.

b) Compute the value of $\int_{0.2}^{1.4}(\sin x - \log x + e^x)\,dx$ using Simpson's $\frac{3}{8}$*th rule*. 7

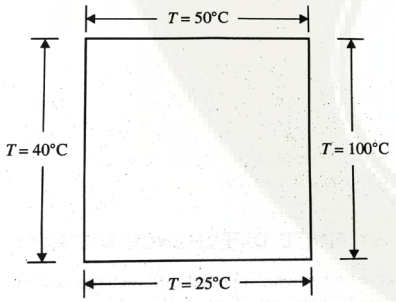
Module V

19 a) Given that $\frac{dy}{dx} = 1 + xy$, $y(0) = 2; y(0.1) = 2.1103; y(0.2) = 2.2430$; $y(0.3) = 2.4011$, find y(0.4) by Adam-Bashforth-Moulton predictor-corrector method. 6

b) Apply Classical Runge-Kutta fourth order method to find approximate value of y for $x = 0.2$ in steps of 0.1, if $\frac{dy}{dx} = x + y^2$, given that $y = 1$ *where* $x = 0$. 8

20 a) Using Euler's modified method, $\frac{dy}{dx} = x + y$, *with* $y(0) = 1$, *and* $x = 0.05$ solve 4

b) A metal plate (1m x 1m) is placed such that its four edges are kept at different temperatures as shown in the figure. The steady state temperature distribution in the plate is given by the Laplace equation: $\frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2} = 0$. Choosing square meshes of width 0.25 m, find the temperature (correct to integer values) of the 9 grid points inside the plate. 10



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Syllabus

Module 1 (7 hours)

Errors in numerical calculations,Sources of errors, significant digits and numerical instability - numerical solution of polynomial and transcendental equations - bisection method - method of false position - Newton-Raphson method - fixed-point iteration - rate of convergence of these methods - iteration based on second degree equation - Graeffe's root squaring method for polynomial equations - Bairstow's method for quadratic factors in the case of polynomial equations

Module 2 (7 hours)

Solutions of system of linear algebraic equations. Direct methods - gauss and gauss - Jordan methods - Crout's reduction method - error analysis - iterative methods - Jacobi's iteration - Gauss-seidel iteration - the relaxation method - convergence analysis - solution of system of nonlinear equations by Newton-Raphson method - power method for the determination of Eigen values - convergence of power method.

Module 3 (6 hours)

Polynomial interpolation. Lagrange's interpolation polynomial - divided differences Newton's divided difference interpolation polynomial - error of interpolation - finite difference operators - Gregory – Newton forward and backward interpolations - Stirling's interpolation formula.

Module 4 (6 hours)

Numerical differentiation - differential formulas in the case of equally spaced points - numerical integration - trapezoidal and Simpson's rules - Gaussian integration - errors of integration formulas.

Module 5 (9 hours)

Numerical solution of ordinary differential equations. Euler and modified Euler methods - Runge–Kutta methods (2nd order and 4th order only) - multistep methods - Adam-Bashforth& Adam-Moulton formulas. Solution of boundary value problems in ordinary differential equations - finite difference methods for solving two dimensional Laplace's equation for a rectangular region - finite difference method of solving heat equation and wave equation with given initial and boundary conditions.

Text Books:

1. William L. Luyben, Process Modeling Simulation and Control for Chemical Engineers-McGraw-Hill (1999).

2. B. Wayne Bequette, Process Dynamics_-Modeling, Analysis and Simulation-Prentice Hall (1998)

Reference Books

1. Steven Chapra and Raymond Canale, Numerical Methods for Engineers, 8th Edition, Mc Graw Hill.
2. Ajay K. Ray, Mathematical Methods in Chemical & Environmental Engineering, Thomson-Learning
3. Froberg C.E., Introduction to Numerical Analysis, Addison Wesley
4. Gerald C.F., Applied Numerical Analysis, Addison Wesley
5. Hildebrand F.B., Introduction to Numerical Analysis, T.M.H.
6. James M.L., Smith C.M. & Wolford J.C., Applied Numerical Methods for Digital Computation, Harper & Row
7. Mathew J.H., Numerical Methods for Mathematics, Science and Engineering, P.H.I

Course Contents and Lecture Schedule

Sl.No	Topic	No. of Lectures
1	**Module I (7 Hours)**	
1.1	Errors in numerical calculations, Sources of errors, significant digits and numerical instability.	1
1.2	Numerical solution of polynomial and transcendental equations - bisection method - method of false position - Newton-Raphson method - fixed-point iteration - rate of convergence of these methods -	4
1.3	Iteration based on second degree equation - the Graeffe's–root squaring method for polynomial equations.	1
1.4	Bairstow's method for quadratic factors in the case of polynomial equations.	1
2	**Module II (7 Hours)**	
2.1	Solutions of system of linear algebraic equations. Direct methods - gauss and gauss - Jordan methods - Crout's reduction method - error analysis -	2
2.2	Iterative methods - Jacobi's iteration - Gauss-seidel iteration - the relaxation method - convergence analysis.	2
2.3	Solution of system of nonlinear equations by Newton-Raphson method.	2
2.4	Power method for the determination of Eigen values - convergence of power method	1
3	**Module III (6 Hours)**	
3.1	Polynomial interpolation. Lagrange's interpolation polynomial -	2
3.2	Divided differences Newton's divided difference interpolation polynomial - error of interpolation -	2
3.3	Finite difference operators - Gregory – Newton forward and backward interpolations - Stirling's interpolation formula.	2
4	**Module IV (6 Hours)**	
4.1	Numerical differentiation - differential formulas in the case of equally	2

	spaced points.	
4.2	Numerical integration - trapezoidal and Simpson's rules.	2
4.3	Gaussian integration - errors of integration formulas	2
5	**Module V (9 Hours)**	
5.1	Numerical solution of ordinary differential equations - Euler and modified Euler methods - Runge–Kutta methods (2nd order and 4th order only).	3
5.2	Multistep methods - Adam-Bashforth& Adam-Moulton formulas.	1
5.3	Solution of boundary value problems in ordinary differential equations - finite difference methods for solving two dimensional Laplace's equation for a rectangular region.	2
5.4	Finite difference method of solving heat equation and wave equation with given initial and boundary conditions	3

CHT342	MATERIAL SCIENCE AND ENGINEERING	CATEGORY	L	T	P	CREDIT
		PEC	2	1	0	3

Preamble: Material Science is an interdisciplinary field. It deals with the design and discovery of new materials. Material science incorporates elements of physics, chemistry and engineering. The course deals with various aspects of material science such as atomic structure, properties of materials, selection of materials etc.

Prerequisite: A basic knowledge in physics and chemistry.

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

CO 1	Define qualitatively the structure and bonding schemes of solids.
CO 2	Explain physical properties and possible applications of a given material.
CO 3	Determine the stability of materials with all sorts of environments using phase diagrams.
CO 4	Identify and compare the properties of alloys, ceramics, polymers, composite materials and their engineering applications.
CO 5	Select suitable material for construction in chemical industries.

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	3						1					
CO 3	3						3					
CO 4	3						3					
CO 5	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): Define qualitatively the structure and bonding schemes of solids.

1. Define coordination number
2. Differentiate between crystalline and amorphous solids
3. Draw and explain the miller indices of unit cell of cubic crystal lattice

Course Outcome 2 (CO2) : Explain physical properties and possible applications of a given material.

1. Compare isotropy and anisotropy
2. Differentiate between ductility and malleability
3. Explain the technological properties of solid materials

Course Outcome 3 (CO3): Predict the stability of materials with all sorts of environments using phase diagrams.

1. State and explain Hume Rothery rules
2. Draw and explain eutectic system with examples
3. Draw and explain Iron carbon diagram

Course Outcome 4 (CO4): Identify and compare the properties of alloys, ceramics, polymers, composite materials and their engineering applications.

1. Write a note on aluminium and its alloys
2. Classify ceramic and non-ceramic structures

3. List some materials used for high temperature applications

Course Outcome 5 (CO5): Select suitable material for construction in chemical industries

1. What are the factors affecting selection of materials for construction in chemical industry?
2. What are the factors affecting corrosion?
3. Explain aging of rubber

Model Question Paper

QP CODE: **PAGES:2**

Reg No:_____
Name :_____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
SIXTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR
Course Code: CHT 342

Max. Marks: 100
Duration: 3 Hours

MATERIAL SCIENCE AND ENGINEERING
(2019-Scheme)
PART A

(Answer all questions , each question carries 3 marks)

1. Distinguish between crystalline and amorphous solids
2. Explain Schottky defect.
3. Distinguish between castability, machinability.
4. List three mechanical properties of materials and define them
5. Draw and explain Iron-Carbon diagram
6. State and explain Hume Rothery rules
7. Compare ceramic and non-ceramic structures
8. List some materials used for high temperature applications
9. What are corrosion inhibitors?
10. Explain aging of rubber

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

Module - I

11. Describe the various bonding patterns in solids

12. Explain with neat sketches the 14 Bravais lattices in a cubic crystal lattice.

Module - II

13. (a) Write a note on the mechanical properties of engineering materials.

    (b) Distinguish between paramagnetism and ferromagnetism

14. (a) Describe stress-strain relationship using suitable diagram.

    (b) Define Poisson's ratio.

Module -III

15. What are solid solutions? Give an account of various types of solid solutions.

16. Distinguish between eutectic and peritectic systems using a phase diagram

Module -IV

17. What are alloys?. Briefly describe aluminium and its alloys.

18. What are composite materials? Describe four applications of composite materials

Module -V

19. Describe the mechanism and factors influencing corrosion

20. Explain the factors affecting the selection of materials.

(14x5 =70)

Syllabus

Module 1 :Crystal Structure (5 hours)

Structure of atom-present concept of atom-Rutherford's and Bhor's model, Bonding in solids-Types of solids-crystalline and amorphous solids-crystal systems - Bravais lattices-miller indices-coordination number-crystal defects-determination of crystal structure-X-ray diffraction-electron diffraction methods.

Module 2: **Properties of Engineering Materials (8 hours)**

Properties of engineering materials-mechanical properties -isotropy and anisotropy-elasticity, plasticity, toughness, resilience, tensile strength, ductility, malleability, brittleness, hardness, fatigue, creep, wear resistance- Poisson's ratio-stress-strain relation-true stress and true strain-electrical and magnetic properties-resistivity-conductivity-ionic and electrical conductivity, semiconductors, superconductivity, insulators, ferroelectricity, piezoelectricity, magnetization, paramagnetism, ferromagnetism, and diamagnetism -technological properties-castability, machinability, weldability, solderability, workability, formability.

Module 3 : Solid solutions (8 hours)

Solid solutions-types of solid solutions-Hume Rothery rules-intermediate phases-mechanical mixtures-phase diagrams-eutectic systems- peritectic system, eutectoid and peritectoid systems - carbon diagram-T-T-T diagram-plastic deformation-recrystallisation-hot and cold working of metals, Heat treatments-elementary study of various metals and alloys like cast iron,carbon steel,alloy steels.

Module 4 : Alloys and Composites (7 hours)

Non-ferrous metals and alloys-aluminium and its alloys-copper and its alloys-Non ferrous metals and alloys used for high temperature services and nuclear application
Polymers and their properties-ceramics-classification-comparison of ceramic and non-ceramic structures-properties and application of ceramics Composite materials-classification-general characteristics, Introduction to Nanocomposites.

Module 5: Selection of Materials (7 hours)

Corrosion-different types, mechanism and factors influencing corrosion-corrosion prevention-inhibitors and their applications-oxidation-aging of rubber-oxidation of metals and radiation damage-factors affecting the selection of materials for engineering purposes selection of suitable materials for construction in chemical industry.

Text Books

1. Khanna O.P., A Text Book of Material Science & Metallurgy, Dhanpat Rai publishers
2. Hajra Choudhary, Material Science & Processes, Dhanpat Rai publishers

Reference Books

1. Van Vlack, Elements of Material Science, Pearson publishers
2. Material Science and Engineering, William F. Smith, Javad Hashemi, Ravi Prakash, Mc Graw Hill
3. Material Science and Engineering, Nehal Dash Kaushik Kumar, Apurba Kumar Roy, Wiley
4. Callister's Material Science and Engineering, R. Balasubramaniam, Wiley

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Crystal Structure (5 hours)**	
1.1	Structure of atom-present concept of atom-Rutherford's and Bhor's model	1
1.2	Bonding in solids- Types of solids-crystalline and amorphous solids-crystal systems	2
1.3	Bravais lattices-miller indices-coordination number-crystal defects-determination of crystal structure-X-ray diffraction-electron diffraction methods	2
2	**Properties of Engineering Materials** (8 hours)	
2.1	Mechanical properties -isotropy and anisotropy-elasticity, plasticity, toughness, resilience, tensile strength, ductility, malleability, brittleness, hardness, fatigue, creep, wear resistance	2
2.2	Poisson's ratio-stress-strain relation-true stress and true strain-electrical and magnetic properties-resistivity -conductivity-ionic and electrical conductivity, semiconductors, superconductivity, insulators	2
2.3	Ferroelectricity, piezoelectricity, magnetization, paramagnetism, ferromagnetism, and diamagnetism	2
2.4	Technological properties-castability, machinability, weldability, solderability, workability, formability	2
3	**Solid Solutions (8 hours)**	
3.1	Solid solutions-types of solid solutions-Hume Rothery rules-intermediate phases-mechanical mixtures	1
3.2	Phase diagrams-eutectic systems-peritectic system	1
3.3	Eutectoid and peritectoid systems	1
3.4	Iron - carbon diagram-T-T-T diagram	2
3.5	Plastic deformation-recrystallisation-hot and cold working of metals	1

3.6	Heat treatments-elementary study of various metals and alloys like cast iron,carbon steel,alloy steels.	2
4	**Alloys and Composites (7 hours)**	
4.1	Non-ferrous metals and alloys-aluminium and its alloys-copper and its alloys	1
4.2	Non ferrous metals and alloys used for high temperature services and nuclear application	2
4.3	Organic polymers and its properties-ceramics-classification-comparison of ceramic and non-ceramic structures-	2
4.4	Properties and application of ceramics-composite materials-classification-general characteristics. Introduction to nanomaterials.	2
5	**Selection of Materials (7 hours)**	
5.1	Corrosion-different types, mechanism and factors influencing corrosion	2
5.2	Corrosion prevention-inhibitors and their applications-oxidation-aging of rubber-oxidation of metals and radiation damage	2
5.3	Factors affecting the selection of materials for engineering purposes selection of suitable materials for construction in chemical industry.	3

CHT352	OPERATIONS RESEARCH	CATEGORY	L	T	P	CREDIT
		PEC	2	1	0	3

Preamble: Operational Research (OR) is a discipline to aid decision making and improving efficiency of the system by applying advanced analytical methods. The tools of Operational Research are not from any one discipline; rather Mathematics, Statistics, Information Technology, Economics, Engineering, etc. have contributed to this discipline of knowledge. This course aims at familiarizing the students with quantitative tools and techniques, which are frequently applied to business decision-making and to provide a formal quantitative approach to problem solving and an intuition about situations where such an approach is appropriate.

Prerequisite: Nil

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

CO 1	Recognize the importance and value of Operations Research and mathematical modelling to optimally solve a wide variety of engineering and management problems.
CO 2	Formulate Linear Programming models and apply operations research techniques and algorithms to solve LP problems.
CO 3	Understand the concept of duality and conduct post optimal analysis
CO 4	Formulate transportation, assignment problems and drive their optimal solution.
CO 5	Formulate Network models and apply operations research techniques and algorithms to solve Network 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	PO 10	PO 11	PO 12
CO 1	3	3	3	2								
CO 2	3	3	3	2								
CO 3	3	3	3	2	1							
CO 4	3	3	3	2	2						3	
CO 5	3	3	3	2	1						3	

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): Recognize the importance and value of Operations Research and mathematical modelling to optimally solve a wide variety of engineering and management problems.

1. Define Operations research. Write any two area of feasible application of OR.
2. Explain different phases of Operation Research.
3. Write down the basic structure of a linear programming problem in the mathematical form.
4. Write down the applications of OR with examples.

Course Outcome 2 (CO2): Formulate Linear Programming models and apply operations research techniques and algorithms to solve these LP problems.

1. Solve the following problem by Simplex method and comment on the result.
   Maximize: $Z = 5X1 + 3X2$
   Subject to: $4X_1 - X_2 \leq 10$; $2X_1 + 2X_2 \leq 50$; $X_1, X_2 \geq 0$

2. A pharmaceutical company has 100kg of A, 180kg of B and 120kg of C ingredients available per month. The company can use these materials to make three basic pharmaceutical products namely 5-10-5, 5-5-10 and 20-5-10, where the numbers in each case represent the percentage of weight of A, B and C respectively in each of the products. The cost of these raw materials is as follows.

Ingredients	Cost/kg (Rs.)
A	80
B	20
C	50
Inert	20

The selling prices of these products are Rs.40.50, Rs.43 and Rs.45/kg respectively. There is a capacity restriction of the company for product 5-10-5 because of which company cannot produce more than 30kg per month. Determine how much of each of the product the company should produce in order to maximize its monthly profit. Use simplex method for solving the problem.

3. Solve the following LPP by simple method:
Maximize $Z = 3X_1 + 2X_2$
Subject to: $2X_1 + X_2 \leq 5$, $X_1 + X_2 \leq 3$ and $X_1, X_2 \geq 0$

Course Outcome 3(CO3): Understand the concept of duality and conduct post optimal analysis.

1. Write the dual of the following LPP
Minimize $Z = 3X_1 - 2X_2 + 6X_3$
Subject to: $4X_1 + 5X_2 + 3X_3 \geq 7$; $3X_1 + X_2 + 6X_3 \geq 5$; $7X_1 - 2X_2 - 3X_3 \leq 10$
$X_1 - 2X_2 + 5X_3 \geq 3$; $4X_1 + 7X_2 - 9X_3 \geq 2$ and $X_1, X_2, X_3 \geq 0$
2. Use penalty (Big-M) method to solve the LP problem below.
Minimize $Z = 5X_1 + 3X_2$
Subject to: $2X_1 + 4X_2 \leq 12$; $2X_1 + 2X_2 = 10$; $5X_1 + 2X_2 \geq 10$; X_1 and $X_2 \geq 0$
3. Use two-phase simplex method to solve the following LP problem.
Maximize $Z = 3X_1 + 2X_2 + 2X_3$
Subject to $5X_1 + 7X_2 + 4X_3 \leq 7$; $-4X_1 + 7X_2 + 5X_3 \geq -2$
$3X_1 + 4X_2 - 6X_3 \geq 29/7$; X_1, X_2 and $X_3 \geq 0$
4. State the general rules for formulating a dual LP problem from its primal. Write the dual to the following LP problem.
Maximize $Z = X_1 - X_2 + 3X_3$
Subject to Constraints:
$X_1 + X_2 + X_3 \leq 10$
$2X_1 - X_3 \leq 2$
$2X_1 - 2X_2 - 3X_3 \leq 6$ and $X_1, X_2, X_3 \geq 0$

Course Outcome 4 (CO4): Formulate transportation, assignment problems and drive their optimal solution.

1. Raw materials from four different warehouses are to be transported to five different plants. The availability at each of the warehouses is 25, 30, 20 and 30 tons

respectively. The demands in the corresponding plants are 20,20,30,10 and 25 tons. It is not possible to ship the raw material from warehouse 4 to plant 4. From the unit cost of transportation given below, find the initial basic feasible solution using least cost cell method.

		1	2	3	4	5	Supply
Source	**1**	10	2	3	15	9	25
	2	5	10	15	2	4	30
	3	15	5	14	7	15	20
	4	20	15	13	…	8	30
Demand		20	20	30	10	25	105

2. A Computer Centre has three expert programmers. The centre wants three application programs to be developed. The head of the Computer Centre, after studying carefully the programmes to be developed, estimates the computer time in minutes required by the experts for the application programmes as follows:

		Programmers		
		A	**B**	**C**
Programmes	**1**	120	100	80
	2	80	90	110
	3	110	140	120

Assign the programmers to the programmes in such a way that the total computer time is minimum.

Course Outcome 5 (CO5): Formulate Network models and apply operations research techniques and algorithms to solve these Network problems.

1. Define following terms with respect to CPM/PERT: event, merge event, burst, event, activity, processor activity, successor activity, dummy activity.
2. The flow capacities in a pipe network are shown in table below. Find the maximal flow from node 1 to node 6.

To		**1**	**2**	**3**	**4**	**5**	**6**
From	**1**	...	30	60	15	...	...
	2	20	...	20	25	5	...
	3	40	15	...	20	...	50
	4	25	20	40	...	10	35
	5	...	10	...	40	...	30
	6	...	...	40	35	30	...

3. The details of a project consisting of activities A to K are summarized in table below.

Activity	Immediate Predecessor(s)	Duration	Activity	Immediate Predecessor(s)	Duration
A	...	7	G	C	3
B	...	3	H	E, F	4
C	...	4	I	E, F	5
D	A	2	J	D, H	6
E	A, B	3	K	I, G	3
F	C	5			

Construct the CPM network, determine the critical path and project completion time.

Model Question paper

QP CODE: **PAGES: 3**

Reg No: _____ **Name: _____**

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SIXTH SEMESTER B. TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: CHT 352

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

OPERATIONS RESEARCH

PART – A

Answer All the Questions (10 x 3 = 30)

1. Define Operations research. Write any two area of feasible application of OR.
2. Explain different phases of Operation Research.
3. Explain clearly the following terms in LPP.
   i. Objective function
   ii. Decision Variables
   iii. Slack and Surplus Variables
4. Explain the term duality in linear programming.
5. Write the dual of the following LPP
   Minimize $Z = 3X_1 - 2X_2 + 6X_3$
   Subject to: $4X_1 + 5X_2 + 3X_3 \geq 7$; $3X_1 + X_2 + 6X_3 \geq 5$; $7X_1 - 2X_2 - 3X_3 \leq 10$
   $X_1 - 2X_2 + 5X_3 \geq 3$; $4X_1 + 7X_2 - 9X_3 \geq 2$ and $X_1, X_2, X_3 \geq 0$
6. Describe Big-M method. Explain when do you prefer to use it.
7. Differentiate between Transportation and Transhipment problem
8. List different time estimates used with reference to PERT. Write the expressions for expected duration of a project, and its standard deviation.
9. Differentiate between PERT and CPM.
10. Explain the conditions under which crashing of project is necessary. Write its effect on the project cost.

PART – B

Answer one full question from each module (5 x 14 = 70)

Module 1

11. (a) Maximize $Z = 10X_1 + 15X_2$ Subject to constraints,

$2X_1 + X_2 \leq 26$; $2X_1 + 4X_2 \leq 56$;

$X_1 - X_2 \geq -5$,

$X_1, X_2 \geq 0$

(b) Maximize $Z = 40X_1 + 35X_2$ Subject to constraints,

$2X_1 + 3X_2 \leq 60$,

$4X_1 + 3X_2 \leq 96$,

$X_1, X_2 \geq 0$

OR

12. (a) Use the graphical method to solve the following LP problem.

Maximize $Z=2X_1+X_2$subject to the constraints:

$X_1 + 2X_2 \leq 10$

$X_1 + X_2 \leq 6$

$X_1 - X_2 \leq 2$

$X_1 -2X_2 \leq 1$ and

$X_1, X_2 \geq 0$

(b) The manager of an oil refinery decides on the optimal mix of two possible blending processes of which the inputs and outputs per production run are as follows

Process (units)	Input (units)		Output (units)	
	Crude A	Crude B	Gasoline X	Gasoline Y
1	5	3	5	8
2	4	5	4	4

The maximum amount available for crude A and B are 200 units and 150 units respectively. Market requirements shows that at least 100 units of gasoline X and 80 units of gasoline Y must be produced. The profit per production run for processes 1 and 2 are Rs.300 and Rs.400 respectively. Formulate the LP problem.

Module 2

13. (a) Use penalty (Big-M) method to solve the LP problem below.

Minimize $Z = 5X_1+3X_2$

Subject to: $2X_1+4X_2 \leq 12$; $2X_1+2X_2 = 10$; $5X_1+2X_2 \geq 10$; X_1 and $X_2 \geq 0$

OR

14. Use two-phase simplex method to solve the following LP problem.

Maximize $Z = 3X_1+2X_2+2X_3$

Subject to $5X_1+7X_2+4X_3 \leq 7$

$-4X_1+7X_2+5X_3 \geq -2$

$3X_1+4X_2-6X_3 \geq 29/7$; X_1, X_2 and $X_3 \geq 0$

Module 3

15. State the general rules for formulating a dual LP problem from its primal. Write the dual to the following LP problem.

Maximize $Z = X_1 - X_2 + 3X_3$

Subject to Constraints:

$X_1 + X_2 + X_3 \leq 10$

$2X_1 - X_3 \leq 2$

$2X_1 - 2X_2 - 3X_3 \leq 6$ and

$X_1, X_2, X_3 \geq 0$

OR

16. Write the dual of the following linear programming problem.

Minimize, $Z = 20X_1 + 23X_2$

Subjected to:

$-4X_1 - X_2 \leq -8$

$5X_1 - 3X_2 = -4$

$X_1, X_2 \geq 0$

Solve the Dual problem using simplex method and predict the value of variables X_1 and X_2 from the solution of dual linear programming problem.

Module 4

17. A manufacturing company has three factories, F1, F2 and F3, and two retail outlets, R1 and R2. It wishes to transport its products from its factories to its outlets at minimum total cost. The table below gives details of demand and supply, and also the unit costs of transportation.

		Retail outlet		
		R1	R2	Supply
Factories	F1	2	6	30
	F2	2	4	60
	F3	6	9	20
	Demand	60	20	

(i) Prepare the North-West corner rule solution for the balanced form of this problem.

(ii) Check the optimality of the solution and comment on it.

OR

18. A Computer Centre has three expert programmers. The centre wants three application programs to be developed. The head of the Computer Centre, after studying carefully the programmes to be developed, estimates the computer time in minutes required by the experts for the application programmes as follows:

		Programmers		
		A	**B**	**C**
Programmes	**1**	120	100	80
	2	80	90	110

	3	110	140	120

Assign the programmers to the programmes in such a way that the total computer time is minimum.

Module 5

19. The flow capacities in a pipe network are shown in table below. Find the maximal flow from node 1 to node 6.

To		**1**	**2**	**3**	**4**	**5**	**6**
From	**1**	...	30	60	15	...	...
	2	20	...	20	25	5	...
	3	40	15	...	20	...	50
	4	25	20	40	...	10	35
	5	...	10	...	40	...	30
	6	...	...	40	35	30	...

OR

20. The details of a project consisting of activities A to K are summarized in table below.

Activity	**Immediate Predecessor(s)**	**Duration**	**Activity**	**Immediate Predecessor(s)**	**Duration**
A	...	7	G	C	3
B	...	3	H	E, F	4
C	...	4	I	E, F	5
D	A	2	J	D, H	6
E	A, B	3	K	I, G	3
F	C	5			

Construct the CPM network, determine the critical path and project completion time.

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Syllabus

Module 1 (8 Hrs.)

Introduction to Operations Research: Introduction to OR models, Linear programming - Typical Applications of Linear programming problems, Problem formulation, Graphical and Algebraic method solutions of LPP, Simplex method for LPP.

Module 2 (7 Hrs.)

Special cases in simplex method: Big-M method, Two Phase simplex method, Degeneracy, Multiple solutions, Unbounded solutions, Infeasible solutions, Sensitivity Analysis: Graphical and algebraic approaches.

Module 3 (6 Hrs.)

Duality and Post-optimal analysis: Dual of an LP, Primal-Dual relationships, Economic interpretation of duality, Dual Simplex method, Generalised simplex algorithm, Post-optimal analysis, Changes affecting feasibility and changes affecting optimality.

Module 4 (7 Hrs.)

Transportation model and its variants: Definition, non-traditional transportation models, Transportation algorithm: Determination of the starting solution and iteration computations, Simplex method explanation of method of multipliers, Assignment model: Hungarian method and its simplex explanation.

Module 5 (7 Hrs.)

Network models: Scope and definition, Minimal spanning tree algorithm, Shortest route problem, maximum flow model, CPM and PERT: Network representation, Critical path computation, construction of the time schedule, LP formulation of CPM, PERT calculations.

Text Books

1. Hamdy A. Taha, "Operations Research, an introduction", Eighth Edition, Prentice Hall of India, 2003.
2. Edgar T. F., Himmelblau D. M., Optimisation of Chemical Processes, McGraw Hill.

Reference Books

1. Miller D.M. and Schmidt J. W., Industrial Engineering and Operations Research, John Wiley and Sons, Singapore, 1990.
2. Shennoy G.V. and Srivastava U.K., "Operation Research for Management", Wiley Eastern, 1994.
3. Bazara M.J., Jarvis and Sherali H., "Linear Programming and Network Flows", John Wiley, 1990.
4. Philip D.T. and Ravindran A., "Operations Research", John Wiley, 1992.
5. Hillier and Liebermann, "Operations Research", Holden Day, 1986
6. Budnick F.S., "Principles of Operations Research for Management", Richard D Irwin, 1990.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Introduction to Operations Research (8 Hrs.)**	
1.1	Introduction to OR models, Linear programming - Typical Applications of Linear programming problems	2
1.2	Problem formulation	2
1.3	Graphical method solutions of LPP	1
1.4	Algebraic method solutions of LPP	1
1.5	Simplex method for LPP	2
2	**Special cases in simplex method (7 Hrs.)**	

2.1	Big-M method	2
2.2	Two Phase simplex method	1
2.3	Degeneracy, Multiple solutions	1
24	Unbounded solutions, Infeasible solutions	1
2.5	Sensitivity Analysis: Graphical and algebraic approaches	2
3	**Duality and Post-optimal analysis (6 Hrs.)**	
3.1	Dual of an LP, Primal-Dual relationships	1
3.2	Economic interpretation of duality	1
3.3	Dual Simplex method	1
3.4	Generalised simplex algorithm	1
3.5	Post-optimal analysis	1
3.6	Changes affecting feasibility and changes affecting optimality	1
4	**Transportation model and its variants (7 Hrs.)**	
4.1	Definition, non-traditional transportation models	1
4.2	Transportation algorithm: Determination of the starting solution and iteration computations	2
4.3	Simplex method explanation of method of multipliers	2
4.4	Assignment model: Hungarian method and its simplex explanation	2
5	**Network models (7 Hrs.)**	
5.1	Scope and definition	1
5.2	Minimal spanning tree algorithm	1
5.3	Shortest route problem	1
5.4	Maximum flow model	1
5.5	CPM and PERT: Network representation, Critical path computation	1
5.6	Construction of the time schedule	1
5.7	LP formulation of CPM, PERT calculations.	1

CHT 362	PROCESS INSTRUMENTATION	CATEGORY	L	T	P	CREDIT
		PEC	2	1	0	3

Preamble: This course covers the key aspects of chemical process instrumentation. The course will provide a comprehensive introduction to principles and practices of measurement of important chemical process variables such as pressure, temperature, flow, level, density, viscosity, humidity etc.

Prerequisite: NIL

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

CO 1	Explain the functional elements of measurement systems, the classification of Instruments and calibration of various instruments.
CO 2	Understand the basic fundamentals, terms, and units of pressure, temperature, density, viscosity, humidity, level, and flow rate.
CO 3	Identify, select and install commonly used process variable measurement devices for a specified purpose.
CO 4	Illustrate the construction and working principle of various type of instruments to measure physical quantities like pressure, temperature, density, viscosity, humidity, level, and flow rate.
CO 5	Explain and sketch various measuring instruments used for density, viscosity, humidity and their safe application.

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		2									3
CO 3	3	3	3									3
CO 4	3											3
CO 5	3											3

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	20	20	30
Understand	10	10	30
Apply	10	10	20

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): Explain the functional elements of measurement systems, the classification of Instruments and calibration of various instruments.

1. Explain the significance of the primary and secondary elements of an instrument.
2. Explain static and dynamic characteristics of an instrument.
3. Explain different types of direct & indirect level measurement techniques

Course Outcome 2 (CO2): Understand the basic fundamentals, terms, and units of pressure, temperature, density, viscosity, humidity, level, and flow rate.

1. List different temperature scales and their relations with each other.
2. Define and explain terms: (1) Gauge pressure (2) Absolute pressure (3) Static pressure.
3. What are the different units of pressure and what do you mean by force summing device?

Course Outcome 3(CO3): Identify, select and install commonly used process variable measurement devices for a specified purpose.

1. Describe any two instruments that are used for low pressure measurement.
2. Give justification for why you would choose a venturi-meter over an orifice meter for measuring flow of a fluid that has to be transported over long distances.
3. Suggest a pressure gauge for measuring the pressure in the range of 650kg/cm^2 to 16500 kg/cm^2. Explain the working of the same

Course Outcome 4 (CO4): Illustrate the construction and working principle of various type of instruments to measure physical quantities like pressure, temperature, density, viscosity, humidity, level, and flow rate.

1. Explain the working principle of McLeod Gauge with neat sketch & list the merits & demerits.
2. With neat sketch explain construction and working of Rotameter
3. With a neat diagram, explain the working of radiation pyrometer. List out the advantages and disadvantages of radiation pyrometer.

Course Outcome 5 (CO5): Explain and sketch various measuring instruments used for density, viscosity, humidity and their safe application.

1. Briefly describe about the construction and working principle of Ultrasonic densitometer.
2. Explain the working principle of the hair-tension hygrometer with the help of aneat figure.
3. Explain the different types of viscometer.

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CHEMICAL ENGINEERING

Model Question Paper

QP CODE: PAGES: 3

Reg No: _____ Name: _____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SIXTH SEMESTER B. TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: CHT 362

Max. Marks: 100 Duration: 3 Hours

PROCESS INSTRUMENTATION

PART – A

Answer All the Questions (10 x 3 = 30)

1. Define and explain terms: (1) Hysteresis (2) Reproducibility (3) Resolution
2. Explain the roles of a functioning element
3. Describe any two instruments that are used for low pressure measurement
4. List the advantages & disadvantages of McLeod Gauge.
5. List different temperature scales and their relations with each other
6. List the ranges and accuracy of any five types of temperature measuringinstruments.
7. Explain different types of open channel flow measurements.
8. Classify mechanical flow meters.
9. Differentiate kinematic viscosity from specific viscosity.
10. What is psychrometer? How does it differ from hygrometer?

PART – B

Answer one full question from each module (5 x 14 = 70)

Module 1

11 a) How do instruments respond to continuous change in process parameters? Explain each Characteristic.

b) Explain about various sources of static error. **(10+4 = 14 marks)**

OR

12 a)With a neat figure, explain the functional elements of an instrument with a suitable example. **(14 marks)**

Module 2

13. Explain the working principle of McLeod Gauge with neat sketch & list the merits & demerits. **(14 marks)**

OR

14 a) Explain the working principle of Knudsen gauge with a neat sketch.

b) Explain the working principle of diaphragm gauge used for pressure measurement with a neat figure. **(7+7=14 marks)**

Module 3

15 a) Explain the construction and working of bimetallic thermometer with a neat sketch. List different materials used for the construction of bimetallic thermometer

b) Explain the sources of errors and precautions to be taken in temperature measurements using liquid filled thermometers. **(7+7=14 marks)**

OR

16. With a neat diagram, explain the working of radiation pyrometer. List out the advantages and disadvantages of radiation pyrometer.

(14 marks)

Module 4

17.a)With the help of neat labelled diagrams, explain the working principle and applications of the pitot tube for flow velocity measurement.

b) Differentiate variable area meters & variable head meters with examples for each.

(10+4=14 marks)

OR

18. a) With the help of a figure describe the working of bubbler system for level mesurement

b)Explain working of ultrasonic level detectors.

(7+7=14 marks)

Module 5

19. Illustrate with neat sketch about Saybolt Viscometer. **(14 marks)**

OR

20. Describe the principle of humidity measurement and also explain the working principle of any one type of hygrometer with neat sketch. **(14 marks)**

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Syllabus

Module 1 (6 hours)

Principles of measurements and classification of process instruments, Functional elements of instruments, Basic methods of measurements, static and dynamic characteristics of measurement system,Errors in measurement, Calibration- Methods of Calibration-Calibration Procedures, Introduction to Data acquisition systems: objectives of DAS, elements of analog DAS, elements of digital DAS.

Module 2 (7 hours)

Units of pressure, Measurement of pressure-Manometers, Bourdon gauges, Diaphragm gauges, Bellow gauges, Bell gauges, Electrical methods:- Elastic elements with LVDT and strain gauges, Capacitive type pressure gauge:- Piezo resistive pressure sensor-Resonator pressure sensor Vaccum gauges:- McLeod gauge, Knudsen gauge, Pirani gauge, thermocouple gauge, ionization gauge, Calibration of pressure gauges.

-

Module 3 (7 hours)

Measurement of temperature: Temperature scales, Temperature standard, Bimetallic thermometer, filled-in thermometers, Sources of errors in - filled in systems and their compensation,vapour pressure thermometers, resistance thermometers, thermistors, thermocouples - types and ranges - characteristics, laws of thermocouples, thermowell, radiation pyrometer, optical pyrometer, temperature transmitter.

Module 4 (9 hours)

Measurement of flow: Variable head flow meters:- orifice plate, venturi tube, dahl tube, flow nozzle, pitot tube, Variable Area flow meter:-Rotameter,Mass flow meter - Angular momentum, Coriolis type mass flow meters, Positive displacement flow meters:- Nutating disc, Reciprocating piston and Oval gear flow meters, Turbine flow meter.Electromagnetic flow meter:- Ultrasonic flow meters, Laser Doppler anemometer ,Vortex shedding flow meter, Open channel flow measurements, Solid flow measurement.
Measurement of level: Sight glass, float gauge, displacer, torque tube, bubbler tube, diaphragm box, D/P methods, electrical methods - resistance type, capacitance type, ultrasonic level gauging. Boiler drum level measurement:- Differential pressure method and Hydrastep method, Solid level measurement

Module 5 (6 hours)

Units of density and specific gravity, Baume scale and API scale,Pressure type densitometers, Float type densitometers , Ultrasonic densitometer, gas densitometer.
Measurement of Viscosity:-Saybolt viscometer-Rotameter type viscometer, Consistency meters
Measurement of Humidity:- Dry and wet bulb psychrometers, Resistive and capacitive type hygrometers, Dew cell , Commercial type dew meter, Moisture measurement in solids: Conductivity sensor, Microwave and IR sensors

Text Books:

1. William C. Dunn, Fundamentals of Industrial Instrumentation and Process Control – 1st Edition, McGraw Hill(2005).
2. Donald P Eckman, Industrial Instrumentation, CBS Publishers and Distributors, New Delhi.

Reference Books:

1. Jain R K, Mechanical and Industrial measurements, Khanna publishers.
2. Patranabis D, Principles of Industrial Instrumentation, Tata- McGraw Hill.
3. Ernest O Doeblin, Measurement systems, Application and Design, McGraw Hill.
5. C.S. Rangan,G.R.Sarma and V.S.V. Mani – Instrumentation Devices and Systems – Tata McGraw Hill.

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Course Contents and Lecture Schedule:

No.	Details	No. of Lectures
1	**Module 1**	**6**
1.1	Principles of measurements and classification of process instruments, Functional elements of instruments	1
1.2	Basic methods of measurements, static and dynamic characteristics of measurement system,	1
1.3	Errors in measurement	1
1.4	Calibration- Methods of Calibration- Calibration Procedures,	1
1.5	Introduction to Data acquisition systems: objectives of DAS, elements of analog DAS, elements of digital DAS.	2
2	**Module 2**	**7**
2.1	Units of pressure, Measurement of pressure-Manometers, Bourdon gauges, Diaphragm gauges, Bellow gauges, Bell gauges.	2
2.2	Electrical methods:- Elastic elements with LVDT and strain gauges,	2
2.3	Capacitive type pressure gauge:- Piezo resistive pressure sensor- Resonator pressure sensor	1
2.4	Vaccumgauges:- McLeod gauge, Knudsen gauge, Pirani gauge, thermocouple gauge, ionization gauge, Calibration of pressure gauges	2
3	**Module 3**	**7**
3.1	Measurement of temperature: Temperature scales, Temperature standard,	1
3.2	Bimetallic thermometer, filled-in thermometers, Sources of errors in - filled in systems and their compensation,	2
3.3	vapour pressure thermometers, resistance thermometers, thermistors,	1
3.4	thermocouples - types and ranges - characteristics, laws of thermocouples, thermowell,	2
3.5	radiation pyrometer, optical pyrometer, temperature transmitter.	1
4	**Module 4**	**9**
4.1	Measurement of flow: Variable head flow meters:- orifice plate, venturi tube, dahl tube, flow nozzle, pitot tube,	1
4.2	Variable Area flow meter:-Rotameter,Mass flow meter - Angular momentum, Coriolis type mass flow meters,	1
4.3	Positive displacement flow meters:-Nutating disc, Reciprocating piston and Oval gear flow meters, Turbine flow meter.	1
4.4	Electromagnetic flow meter:- Ultrasonic flow meters, Laser Doppler anemometer ,Vortex shedding flow meter,	1
4.5	Open channel flow measurements, Solid flow measurement.	1
4.6	Measurement of level: Sight glass, float gauge, displacer, torque tube,	2

	bubbler tube, diaphragm box, D/P methods, electrical methods - resistance type, capacitance type, ultrasonic level gauging.	
4.7	Boiler drum level measurement:- Differential pressure method and Hydrastep method, Solid level measurement	2
5	**Module 5**	**6**
5.1	Units of density and specific gravity, Baume scale and API scale,Pressure type densitometers, Float type densitometers , Ultrasonic densitometer, gas densitometer.	2
5.2	Measurement of Viscosity:-Saybolt viscometer-Rotameter type viscometer, Consistency meters	2
5.3	Measurement of Humidity:- Dry and wet bulb psychrometers, Resistive and capacitive type hygrometers, Dew cell , Commercial type dew meter, Moisture measurement in solids: Conductivity sensor, Microwave and IR sensors	2

CHT372	CATALYST SCIENCE AND CATALYTIC PROCESSES	CATEGORY	L	T	P	CREDIT
		PEC	2	1	0	3

Preamble: The science and technology of catalysis is of great significance as it affects our daily life. Four major sectors of the world economy; petroleum and energy production, chemicals and polymer production, food industry and pollution control, involve catalytic processes. Catalysis involves understanding of the thermodynamics, kinetics, electronic interaction, crystal structure, reactor design and process development for a catalytic process. The Topics included in the course are different types of Catalysis, Thermodynamics of adsorption, reparative methods and Characterisation of catalysts, industrial catalysis and modern trends in catalysis.

Prerequisite: Nil

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

CO 1	Apply the basic concepts & theory for characterization of catalysts.
CO 2	Describe the preparation of catalysts for various unit processes.
CO 3	Explain various catalytic processes in industries.
CO 4	Describe the deactivation of catalysts.
CO 5	Analyse modern trends in catalysis

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											
CO 4	3											
CO 5	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. Classify catalysts on the basis of catalytic structure.

2. Describe Langmuir adsorption isotherm in various forms.

3. what are the different steps in catalytic reaction.

Course Outcome 2 (CO2)

1. Describe Sol gel process with a neat sketch and flow charts.

2. Describe co-precipitation with example.

3. What are catalytic agents? Give examples.

Course Outcome 3(CO3):

1. List any three transition metal catalysts with application.

2. List any five industrial application of Zeolite

Course Outcome 4 (CO4):

1. What is the significance of regeneration of catalysts?

2. Describe poisoning method of catalyst deactivation.

Course Outcome 5 (CO5):

1. Describe photo catalytic reaction with an example

2. List the advantages of nano catalysis over conventional catalytic processes.

3. Describe Sintering method of catalyst deactivation.

Model Question paper

QP CODE: **PAGES: 3**

Reg No: _____ **Name: _____**

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SIXTH SEMESTER B. TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: CHT 372

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

CATALYST SCIENCE AND CATALYTIC PROCESSES

PART – A

Answer All the Questions (10 x 3 = 30)

1. Write notes on catalyst selectivity.
2. Differentiate physisorption & Chemisorption
3. With example explain flame hydrolysis.
4. Mention industrial application of zeolite.
5. What are catalytic promoters.
6. Define Bragg's law.
7. What you mean by deactivation of catalyst.
8. What is sintering of catalysts.
9. Give any three examples for biocatalysts.
10. What are the types of phase transfer catalysis.

PART B

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

Module -I

11. a)Explain any two adsorption isotherms. (10 marks)

b) explain different steps involved in heterogenous catalytic reaction.(4marks)

12. a).write the general characteristics of catalysis (7marks)

b). explain classification of catalysts. (7marks)

Module -II

13 a). Describe precipitation & co-precipitation method of catalyst preparation with suitable examples. (7marks)

b). Explain sol gel method of catalyst synthesis with necessary steps, and suitable example. (7marks)

14. a).Explain chemical vapour decomposition technique with example. (7marks)

b). Explain zeolite preparation. Mention its uses as a catalysts. (7marks)

Module -III

15. a).Explain BET method to find the surface area of catalysts. (7marks)

b).Explain XRD for catalyst characterization. (7marks)

16. a).Explain Chemisorption techniques for catalyst characterization. Classify the method according to gases used. (6marks)

b). State the importance of catalyst characterization. Classify different characterization methods. (7marks)

Module -IV

17. a). Describe on catalyst deactivation? Classify based on mechanisms. (6marks)

b). Explain the mechanism of coke formation on catalysts with neat sketches. (8marks).

18. a). Explain regeneration of deactivated catalysis. (9marks)

b). Explain coke formation on catalysts. (5marks)

Module -V

19. a). Explain transition metal catalysts & list any two industrial application. (7marks)
b). Explain the different transfer catalysis with industrial application. (7marks)

20. a). Differentiate homogenous & heterogenous catalysis. Explain any two heterogenous catalysts with industrial application. (7marks)

b). describe bio catalysis & phocatalysis with industrial application. (7marks)

Syllabus

Module 1 (6 Hrs.)

General characteristics of catalysis, Classification of Catalyst, Thermodynamics of adsorption, Physical adsorption and chemisorption.

Module 2 (7 Hrs.)

Catalyst preparative Methods-Precipitation and co precipitation, Sol gel process, Flame hydrolysis, Supported catalyst from CVD and related techniques, methods preparation and structure of supports, Synthesis of aluminosilicate zeolites.

Module 3 (7 Hrs.)

Catalyst Characterisation- surface area measurements, BET theory, Pore size distribution, Porosimetry, Chemisorption techniques, Static and dynamic methods, Crystallography and surface analysis techniques – XRD, NMR.

Module 4 (7 Hrs.)

Deactivation -classification of catalyst deactivation processes. poisoning of catalysts, poisoning of metallic catalysts, poisoning of non-metallic catalysts, poisoning of bifunctional catalysts, coke formation on catalysts, metal deposition on catalysts ,sintering of catalysts. Regeneration of deactivated catalyst.

Module 5 (8 Hrs.)

Industrial catalysis -Homogeneous, Heterogeneous catalysis, Biocatalysts and their typical industrial applications. Transition metal catalyst, Organo-metallic catalyst, Dual function catalyst, Zeolite and their typical industrial applications. Modern trends in catalysis – Phase transfer catalysis, electro catalysis, Nano catalysis, Polymer supported catalysis, Bio catalysis, Photo catalysis.

Text Books

- Smith, J.M, Chemical Engineering Kinetics, McGraw Hill 2.

Reference Books

1. B. Viswanathan, S. Sivasanker A. V. Ramaswamy, Catalysis: Principles and Applications, Academic Press
2. Diazo Kunii, and Octave Levenspiel, Fluidization Engineering, Butterworth Heinemann
3. Fogler H.S, Elements of Chemical Reaction Engineering, Prentice Hall of India
4. Levenspiel O, Chemical Reaction Engineering, John Wiley.
5. Emmett, P.H , Catalysis Vol I and II, Reinhold Corp, New York, 1954
6. Hill C.G., An Introduction to Chemical Engineering Kinetics & Reactor Design, John Wiley

7. Thomas and Thomas , Introduction to Heterogeneous Catalysis, Academic Press, London, 1967

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Module 1 (6 Hrs.)**	
1.1	General characteristics of catalysis, Classification of Catalyst	2
1.2	Thermodynamics of adsorption, Physical adsorption and chemisorption.	2
1.3	Adsorption isotherms. Catalyst selectivity.	2
2	**Module 2 (7 Hrs.)**	
2.1	Catalyst preparative Methods- Precipitation and co precipitation, Sol gel process	2
2.2	Flame hydrolysis, Supported catalyst from CVD and related techniques,	3
2.3	methods preparation and structure of supports, Synthesis of aluminosilicate zeolites.	2
3	**Module 3 (7 Hrs.)**	
3.1	Catalyst Characterisation- surface area measurements, BET theory, Pore size distribution, Porosimetry	3
3.2	Chemisorption techniques, Static and dynamic methods	2
3.3	Crystallography and surface analysis techniques – XRD, NMR.	2
4	**Module 4 (7 Hrs.)**	
4.1	Deactivation -classification of catalyst deactivation processes.	1
4.2	poisoning of catalysts, poisoning of metallic catalysts, poisoning of non-metallic catalysts, poisoning of bifunctional catalysts,	2
4.3	coke formation on catalysts, metal deposition on catalysts ,sintering of catalysts.	2
4.4	Regeneration of deactivated catalyst.	2
5	**Module 5 (8 Hrs.)**	
5.1	Industrial catalysis -Homogeneous, Heterogeneous catalysis, Biocatalysts and their typical industrial applications	2
5.2	Transition metal catalyst, Organo metallic catalyst, Dual function catalyst, Zeolite and their typical industrial applications	3
5.3	Modern trends in catalysis – Phase transfer catalysis, electro catalysis, Nano catalysis, Polymer supported catalysis, Bio catalysis, Photo catalysis.	3

SEMESTER VI

MINOR

CHT382	HAZARD AND RISK ASSESSMENT	CATEGORY	L	T	P	CREDIT
		VAC	3	1	0	4

Preamble: Chemical Industries are known as the most dangerous and hazardous industries since long.Varieties of conditions are present in chemical industries which may lead to different type of industrial accidents. Most of the industrial accidents are due to the human error or ignorance and responsible for the major losses to the industries and humanity. Itis therefore essential to know about hazards, accidents, safe handling of chemicals, and operation of plant equipment and transportation of chemicals. By taking this course, students will gain a greater ability to identify the various categories of hazards and associated risks in workplaces and apply strategies that are used to make sure hazards and associated risks are eliminated or reduced.

Prerequisite: CHT 282 - Safety Engineering of Process Plants

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

CO1	Identify and assess the risk and hazards of a process and operation.
CO2	Explain different types of indices used in hazard survey.
CO3	Explain different types of hazard identification and risk assessment techniques in the workplace.
CO4	Determine the main process hazard analysis tools used and compare their uses, benefits and limitations.
CO5	Describe how risk assessment steps apply to process safety hazards and define the main concepts related to process safety risk assessment including protection layers, threats, consequences and effects, etc.

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	2	--	--	--	--	2
CO 2	3	--	--	2	--	2	2	--	--	--	--	2
CO 3	3	--	--	2	--	2	2	--	--	--	--	2
CO 4	3	--	--	2	--	2	2	--	--	--	--	2
CO 5	3	--	--	2	--	2	2	--	--	--	--	2

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	20
Understand	20	20	40

Apply	20	20	40
Analyze			
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): Identify and assess the risk and hazards of a process and operation and determine the underlying causes of the hazards.

1. Describe the features of the following: (i) Pool fire (ii) Jet fire (iii) Flash fire and (iv) Deflagration.
2. Explain in detail about classification of hazards in chemical process industries.
3. Explain the major consequences of explosion hazards.

Course Outcome 2 (CO2): Explain different types of indices used in hazard survey.

1. Write notes on: (i) Mond's index (ii) Hazard identification tools (iii) Preliminary hazard analysis.
2. Explain ALARP triangle and give its significance in risk reduction.
3. Explain Dow Fire Index. Write the advantages and disadvantages of Dow Fire Index.

Course Outcome 3 (CO3): Explain different types of hazard identification and risk assessment techniques in the workplace.

1. Describe the HAZOP procedure and list the guide words.
2. Explain Fault tree analysis used in quantifying Risk.
3. Construct an event tree for LPG release from a storage tank located in a LPG bottling plant. Assume frequency values for different situations

Course Outcome 4 (CO4): Determine the main process hazard analysis tools used and compare their uses, benefits and limitations.

1. Explain the salient features of discharge rate models used for consequence modelling.
2. Explain the cause and consequence of BLEVE.
3. A gas with a molecular weight of 30 is used in a particular process. A source model study indicates that for a particular accident outcome 1.0 kg of gas will be released instantaneously. The release will occur at ground level. The plant fence line is 500 m away from the release. Determine: (i) the time required after the release for the center of the puff to reach the plant fence line. Assume a wind speed of 2 m/s, (ii) the maximum concentration of the gas reached outside the fence line.

Course Outcome 5 (CO5): Describe how risk assessment steps apply to process safety hazards and define the main concepts related to process safety risk assessment including protection layers, threats, consequences and effects, etc.

1. Write any five benefits of implementing LOPA.
2. Explain the significance of Probit functions in risk assessment with suitable example.
3. Explain individual risk and societal risk.

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Model Question Paper

QP CODE: **PAGES: 3**

Reg No: _____Name: _____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SIXTH SEMESTER B. TECH DEGREE EXAMINATION,MONTH & YEAR

Course Code: CHT 382

Max. Marks: 100 Duration: 3 Hours

HAZARD AND RISK ASSESSMENT

PART – A

Answer All the Questions (10 x 3 = 30)

1. Define Hazard, risk and accident.
2. Explain threshold limit values, Short term exposure limit and ceiling level of toxic gases.
3. One thousand Kilograms of methane escapes from a storage vessel, mixes with airand explodes. Determine the equivalent amount of TNT assuming an explosion efficiency of 2%. The Heat of combustion of methane is 818.7KJ/mol and energy of explosion of TNT is 4686KJ/kg.
4. Name the various factors that contribute to Physical hazard with suitable examples.
5. List the major reasons for Bhopal gas tragedy.
6. List out the major objectives of Bow-tie analysis.
7. Differentiate UFL and LFL.
8. Give the methods of preventing BLEVE in process plants.
9. List different steps involved in risk assessment process.

10. Write any five benefits of implementing LOPA.

PART – B

Answer one full question from each module (5 x 14 = 70)

Module 1

11. (a) Describe the features of the following: (i) Pool fire (ii) Jet fire (iii) Flash fire and (iv) Deflagration.
    (b) Explain in detail about classification of hazards in chemical process industries.
    (8 + 6 = 14 Marks)

OR

12. (a) Give the classification and explain the consequences of chemical hazards.
    (b) Explain the major consequences of explosion hazards. **(7 + 7 = 14 Marks)**

Module 1I

13. Write notes on: (i) Mond's index (ii) Hazard identification tools (iii) Preliminary hazard analysis. **(14 Marks)**

OR

14. (a) ExplainALARP triangle and give its significance in risk reduction.
    (b) Explain Dow Fire Index. Write the advantages and disadvantages of Dow Fire Index.
    (6 + 8 = 14 Marks)

Module III

15. Describe the HAZOP procedure and list the guide words. **(14 Marks)**

OR

16. (a) Explain Fault tree analysis used in quantifying Risk.
    (b) Construct an event tree for LPG release from a storage tank located in a LPGbottling plant. Assume frequency values for different situations. **(6 + 8 = 14 Marks)**

Module IV

17. (a) Explain the salient features of discharge rate models used for consequence modelling.
    (b) Explain the cause and consequence of BLEVE. **(7 + 7 = 14 Marks)**

OR

18. A gas with a molecular weight of 30 is used in a particular process. A source model study indicates that for a particular accident outcome 1.0 kg of gas will be released instantaneously. The release will occur at ground level. The plant fence line is 500 m away from the release. Determine: (i) the time required after the release for the center of the puff to reach the plant fence line. Assume a wind speed of 2 m/s, (ii) the maximum concentration of the gas reached outside the fence line. **(14 Marks)**

Module V

19. (a) Explain the significance of Probit functions in risk assessment with suitable example.
    (b) Explain individual risk and societal risk. **(7 + 7 = 14 Marks)**

OR

20. Give the importance of Emergency planning in process industries. Explain the detailed procedure and scope of such a study. **(14 Marks)**

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Syllabus

Module 1(9 Hrs.)

Hazard and risk – Hazard triangle, Types of hazards – Physical hazards, Chemical hazards and Biological hazards. Flammability hazards- Types of fire, Flammability limits, Flammability diagram. Toxic hazards and Industrial hygiene, Different types of doses- Effective dose, Toxic dose and Lethal dose, Evaluation of toxic hazards. Explosion hazards- Classification, Deflagration and Detonation. Reaction hazards and run-away reaction. Radiation hazards.

Module 2 (8 Hrs.)

Hazard Survey – Fire and Explosive index and Toxicity index, Mond index, Chemical exposure index and Inventory analysis. Major accident hazard units (MAH units). ALARP triangle. Major industrial accidents - Reasons, Bhopal and Flixborough disasters.

Module 3 (10 Hrs.)

Techniques for Hazard Identification - Process hazard analysis (PHA), Check lists, Safety audit, Hazard and Operability study (HAZOP), Layer of Protection analysis (LOPA), What-If analysis, Bow-tie analysis, Failure mode and effect analysis, Fault tree analysis and Event tree analysis.

Module 4 (9 Hrs.)

Consequence analysis - Consequence of chemical accidents, Procedure for consequence analysis- Selection of release incidents, Selection of source modelling, Selection of fire and explosion modelling- Pool modelling, modelling of BLEVE and TNT explosion modelling. Selection of Dispersion model.

Module 5 (9 Hrs.)

Risk Assessment – Probitequation,Probit equation for Fire, explosion and Toxic gas release, Risk indices, Individual risk- Risk contour, Average individual risk and Risk profile. Societal risk-F-N curves and Average Societal risk. Emergency planning- Onsite and Offsite emergency plan.

Text Books:

1. Daniel A. Crowl, Joseph F. Louvar, Chemical Process Safety-Fundamentals with Applications, Prentice Hall (2011).

2. Sam Mannan, Lees' Loss Prevention in the Process Industries: Hazard Identification, Assessment and Control, Vol 1-3-Butterworth-Heinemann (2004).

Reference Books

1. K. V. Raghavan and A A. Khan, "Methodologies in Hazard Identification and Risk Assessment", Manual by CLRI, 1990.
2. K S N Raju, Chemical Process Industry Safety, McGraw Hill Education (India) Private Limited.
3. V. C. Marshal, "Major Chemical Hazards", Ellis Horwood Ltd., Chichester, United Kingdom. 1987.
4. Geoff Wells, "Hazard Identification and Risk Assessment", I. ChE., John Ridley and John Channing, "Safety at Work", 6th Edition. Butterworth-Heinemann, 2003.
5. "A Guide to Hazard Operability Studies", Chemical Industry Safety and Health Council, 1977.
6. AIChE/CCPS, Guidelines for Hazard Evaluation Procedures, 2e, Centre for Chemical Process Safety, American Institute of Chemical Engineers, New York, 1992.
7. AIChE/CCPS, Guidelines for Chemical Process Quantitative Risk Analysis, 2e, Centre for Chemical Process Safety, American Institute of Chemical Engineers, New York, 2000.

Course Contents and Lecture Schedule:

No.	Details	No. of Lectures
1	**Module 1 - Hazard and risk (9 Hrs.)**	
1.1	Hazard triangle, Types of hazards – Physical hazards, Chemical hazards and Biological hazards.	2
1.2	Flammability hazards- Types of fire, Flammability limits, Flammability diagram.	2
1.3	Toxic hazards and Industrial hygiene,Different types of doses- Effective dose, Toxic dose and Lethal dose, Evaluation of toxic hazards.	2
1.4	Explosion hazards- Classification, Deflagration and Detonation.	1
1.5	Reaction hazards and run-away reaction. Radiation hazards.	2
2	**Module II - Hazard Survey (8 Hrs.)**	**8**
2.1	Fire and Explosive index and Toxicity index	2
2.2	Mond index, Chemical exposure index and Inventory analysis.	2
2.3	Major accident hazard units (MAH units). ALARP triangle.	2
2.4	Major industrial accidents - Reasons, Bhopal and Flixborough disasters.	2
3	**Module III - Techniques for Hazard Identification(11 Hrs.)**	
3.1	Preliminary hazard analysis (PHA), Check lists, Safety audit	2
3.2	Hazard and Operability study (HAZOP)	2
3.3	Layer of Protection analysis (LOPA)	1
3.4	What-If analysis, Bow-tie analysis, Failure mode and effect analysis	3
3.5	Fault tree analysis and Event tree analysis.	3
4	**Module IV - Consequence analysis (9 Hrs.)**	**9**

4.1	Consequence of chemical accidents, Procedure for consequence analysis	2
4.2	Selection of release incidents, Selection of source modelling	2
4.3	Selection of fire and explosion modelling- Pool modelling, modelling of BLEVE and TNT explosion modelling	3
4.4	Selection of Dispersion model	2
5	**Module V - Risk Assessment (8 Hrs.)**	**9**
5.1	Probit equation, Probit equation for Fire, explosion and Toxic gas release	2
5.2	Risk indices, Individual risk- Risk contour, Average individual risk and Risk profile	2
5.3	Societal risk-F-N curves and Average Societal risk	2
5.4	Emergency planning- Onsite and Offsite emergency plan	2

CHT384	PETROCHEMICAL TECHNOLOGY	CATEGORY	L	T	P	CREDIT
		VAC	3	1	0	4

Preamble: This course introduced with an objective to develop the knowledge to learn scientific and technologicalprinciples of organic synthesis and related unit processes. It provides an understanding on the role of Petrochemical engineer in unit processes used for organicsynthesis and polymerization processes. Students will acquire the ability to understand the unit processes in organic synthesis, varietyof petrochemical feedstock and products, process technologies for Fibers, Elastomers and resins and gets familiar with major polymerization processes on industrial scale

Prerequisite: Nil

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

CO 1	List various petrochemical feed stocks and their preparation and utilization.
CO 2	Summarize the production of various petrochemicals based on Ethylene, Propylene and Butadiene.
CO 3	Identify the production, separation and utilization of aromatics in the petrochemical industries.
CO 4	Outline the process technologies for Fibers, Elastomers and resins and also gets familiar with major polymerization processes on industrial scale.
CO 5	Explain the various process for the production of synthetic detergents.

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					
CO 3	3						2					
CO 4	3						2					
CO 5	3						2					

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	20	20	20
Understand	20	20	50
Apply	10	10	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. Compare the process of synthesis gas production by steam reforming of naphtha and natural gas
2. Demonstrate the difference between LNG, CNG, and NGL
3. Outline the production of methanol from synthesis gas

Course Outcome 2 (CO2)

1. Explain the production of acrylonitrile and acrylic acid
2. Explain the steps involved in the production of ethanol amine from ethylene

Course Outcome 3(CO3):

1. Briefly explain alkylation of benzene
2. Describe the production of benzene, toluene, and xylene from BTX aromatics by distillation.

Course Outcome 4 (CO4):

1. Describe the production of SBR, PBR and Butyl rubber
2. Demonstrate the production of Nylon 6 and Nylon 6,6
3. Explain the production of Phenol Formaldehyde resins

Course Outcome 5 (CO5):

1. Describe the sulphonation of LAB for production of Synthetic Detergents

Model Question paper
QP CODE: PAGES: 3

Reg No: _____

Name: _____

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

Course Code: CHT 384
Max. Marks: 100 Duration: 3 Hours

Petrochemical Technology
(2019-Scheme)

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

1 Demonstrate the difference between LNG, CNG, and NGL

2 List the various chemicals from synthesis gas

3 List six major petrochemical products and their applications

4 Explain the steps involved in the production of ethanol amine from ethylene

5 Write the various uses of xylene

6 Briefly explain alkylation of benzene

7 Write basic difference between LDPE, LLDPE, and HDPE

8 Explain the major steps involved in the production of PVC

9 What are the basic difference between nylon 6 and nylon 6,6?

10 What is LAB and its application?

PART B

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

Module –I

11	a	Compare the process of synthesis gas production by steam reforming of naphtha and natural gas	8
11	b	Outline the production of methanol from synthesis gas	6
12	a	Explain the natural gas processing	14

Module – II

13		Describe the production of ethylene, propylene, and butadiene by naphtha cracking.	14
14		Explain the production of acrylonitrile and acrylic acid	14

Module – III

15	a	Describe the production of benzene, toluene, and xylene from BTX aromatics by distillation.	9
15	b	Explain the production of Phthalic Anhydride	5
16		Describe the production of Styrene, Cumene and Phenol	14

Module – IV

17	a	Describe the production of PVC and Polystyrene	9
17	b	What are the application of LDPE, LLDPE and HDPE?	5
18		Describe the production of SBR, PBR and Butyl rubber	14

Module – V

19		Explain the production of Nylon 6 and Nylon 6,6	14
20	a	Explain the production of Phenol Formaldehyde resins	7
20	b	Describe the sulphonation of LAB for production of Synthetic Detergents	7

Syllabus

Module 1 (10 Hrs.)

Petrochemical Industries & their feed stocks, Natural Gas processing, General idea of LNG, CNG, NGL, LPG and their generation, Production and Utilization of Synthesis gas, Process of Synthesis gas production by steam reforming of Natural Gas, Process of Synthesis gas production by steam reforming of Naphtha, partial oxidation of Fuel Oil, Production of Methanol from Synthesis gas, Chemicals from Synthesis gas by Oxosynthesis, Production of liquid fuels from Synthesis gas by Fischer – Tropsch process

Module 2 (10 Hrs.)

Major Petrochemical products and their applications. First, Second and Third generation petrochemical products, Production of Ethylene, Propylene,andButadiene by Naphtha/Gas cracking, Petrochemicals based on Ethylene, Propylene and Butadiene: Like VCM, VAM,Ethylene Oxide, Ethylene Glycol,Ethanol Amines from Ethylene, Acrylonitile, Isopropanol, Propylene oxide,Glycerine, Acrylic acid,Acrolein from Propylene, Production of Butadiene

Module 3 (8 Hrs.)

Production, Separation and Utilization of Aromatics: - Catalytic Reformation of Naphtha and production of Xylenes, Separation of Xylenes, Isomerization of Meta xylene, Pyrolysis Gazoline hydrogenation and separation of BTX aromatics, Production of Benzene, Toluene, Xylenes from BTX aromatics by distillation, Production of Benzene from Toluene, Uses of xylenes, Alkylation of Benzene, Production of Styrene, Cumene and Phenol, Production of Phthalic Anhydride.

Module 4 (9 Hrs.)

Plastomers, Elastomers and Synthetic fibres: Various methods of polymerization and their mechanisms, Production processes of LDPE, LLDPE and HDPE, Basic difference among the three and their applications, Production of PVC and Polystyrene, Production of Polypropylene, Production of SBR, PBR and Butyl rubber, Production of ABS plastics

Module 5 (8 Hrs.)

Polytetrafluoroethylene, polycarbonate, Purified teraphthalicacid (PTA), Ethylene Glycol, Production of Polyamide (Nylon 6 and Nylon 6,6), Polyester and Acrylic fibres, Production of Phenol Formaldehyde resins, Synthetic Detergents: Classification of detergents, Production of Linear Alkyl Benzene (LAB) from Superior Kerosene and Benzene, Sulphonation of LAB for production of Synthetic Detergents. Additives for synthetic detergents.Hard and soft detergents.

Text Books

1. A Text on Petrochemicals: B.K.B. Rao, Khanna Pub.
1. Petrochemical processes: Chauvel ,Gulf Publishing
2. Introduction to Petrochemicals, SukumarMaity. Oxford and IBH Publishing Co.

Reference Books

1. Advanced Petrochemicals: Dr. G. N. Sarkar, Khanna Publishers
2. The Petroleum chemicals Industry: R. F. Goldstein and A. L. Waddams

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Module 1: (10 Hrs.)**	
1.1	Petrochemical Industries & their feed stocks	1
1.2	Natural Gas processing, General idea of LNG, CNG, NGL, LPG and their generation	2
1.3	Production and Utilization of Synthesis gas, Process of Synthesis gas production by steam reformingof Natural Gas and Naphtha, partial oxidation of Fuel Oil	3

1.4	Production of Methanol from Synthesis gas	1
1.5	Chemicals from Synthesis gas by Oxosynthesis	1
1.6	Production of liquid fuels from Synthesis gas by Fischer – Tropschprocess	2
2	**Module 2: (10 Hrs.)**	
2.1	Major Petrochemical products and their applications. First, Second and Third generation petrochemical products.	1
2.2	Production of Ethylene, Propylene,andButadiene by Naphtha/Gas cracking	1
2.3	Petrochemicals based on Ethylene,Propylene and Butadiene: Like VCM, VAM,Ethylene Oxide, Ethylene Glycol,Ethanol Amines from Ethylene.	4
2.4	Acrylonitile, Isopropanol, Propylene oxide,Glycerine, Acrylic acid,Acrolein from Propylene.	3
2.5	Production of Butadiene	1
3	**Module 3: (8 Hrs.)**	
3.1	Production, Separation and Utilization of Aromatics: - Catalytic Reformation of Naphtha and production of Xylenes, Separation of Xylenes, Isomerization of Meta xylene.	3
3.2	Pyrolysis Gazoline hydrogenation and separation of BTX aromatics	1
3.3	Production of Benzene, Toluene, Xylenes from BTX aromatics by distillation	1
3.4	Production of Benzene from Toluene, Uses of xylenes	1
3.5	Alkylation of Benzene. Production of Styrene, Cumene, Phenol, and Phthalic Anhydride	2
4	**Module 4: (9 Hrs.)**	
4.1	Plastomers, Elastomers and Synthetic fibres: Various methods of polymerization and their mechanisms.	2
4.2	Production processes of LDPE, LLDPE and HDPE, Basic difference among the three and their applications	3
4.3	Production of PVC, Polystyrene, Polypropylene, ABS plastics, SBR, PBR and Butyl rubber	4
5	**Module 5: (8 Hrs.)**	
5.1	Polytetrafluoroethylene, polycarbonate, Purified teraphthalicacid (PTA), Ethylene Glycol.	2
5.2	Production of Polyamide (Nylon 6 and Nylon 6,6), Polyester and Acrylic fibres, Production of Phenol Formaldehyde resins.	2
5.3	Synthetic Detergents: Classification of detergents, Production of Linear Alkyl Benzene (LAB) from Superior Kerosene and Benzene, Sulphonation of LAB for production of Synthetic Detergents. Additives for synthetic detergents. Hard and soft detergents.	4

CHT386	NANOMATERIALS AND NANOTECHNOLOGY	CATEGORY	L	T	P	CREDIT
		VAC	3	1	0	4

Preamble: Nanotechnology has emerged as an important and exciting area in science and engineering. It provides promises in much technological advancement with wide range of application fields. The course gives a basic introduction to chemical and physical principles in the synthesis of nanomaterials. It also covers different methods for synthesis, properties, applications and characterization of nanoscale materials.

Prerequisite: Basic knowledge of material science.

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

CO 1	Understand the concepts of nanotechnology and apply the basic principles of Physics and Chemistry in Nanotechnology
CO 2	Explain synthesis, properties and applications of nanomaterials and nanocomposites
CO 3	Apply nanotechnology in biological fields and acquire the knowledge about drug delivery, biosensors, nanomedicine and therapeutic applications
CO 4	Develop understanding about various characterisation techniques applied to nanomaterials
CO 5	Understand the applications of nanotechnology in energy sector, catalysis and electronics

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											
CO 4	3											
CO 5	3											
CO 6	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): Understand the concepts of nanotechnology and apply the basic principles of Physics and Chemistry in Nanotechnology

1. Write a note on pioneers who contributed for the propagation of the ideas of nanotechnology.
2. Describe the classification of nanomaterials.
3. Briefly describe the ionic properties of nanomaterials

Course Outcome 2 (CO2): Explain synthesis, properties and applications of nanomaterials and nanocomposites

1. Distinguish between top down and bottom up approach in nanomaterial synthesis
2. Describe any one method for the synthesis of nanogold. Mention its applications
3. What are the applications of carbon nanotubes?
4. Compare metal matrix and polymer matrix nanocomposites.

Course Outcome 3(CO3): Apply nanotechnology in biological fields and acquire the knowledge about drug delivery, biosensors, nanomedicine and therapeutic applications

1. Explain the application of nanotechnology in drug delivery.
2. What are biosensors?
3. Discuss on the future of Bio nanotechnology.

Course Outcome 4 (CO4): Develop understanding about various characterisation techniques applied to nanomaterials

1. Explain the principle and operation of XRD.

2. Compare and contrast SEM and TEM

3. Discuss on the thermal analytical techniques for nanomaterials

Course Outcome 5 (CO5): Understand the applications of nanotechnology in energy sector, catalysis and electronics

1. What are the application of nanomaterials in catalysis?
2. Describe Nano Electro Mechanical Systems and their applications.
3. Discuss on the application of nanotechnology in energy conversion.

Model Question Paper

QP CODE: PAGES:2

Reg No:_____
Name :_____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
SIXTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR
Course Code: CHT 386

Max. Marks: 100
Duration: 3 Hours

NANOMATERIALS AND NANOTECHNOLOGY
(2019-Scheme)
PART A

(Answer all questions, each question carries 3 marks)

1. Explain electromagnetic spectrum

2. What is quantum confinement effect?

3. Distinguish between top down and bottom up approach in nanomaterial synthesis
4. Write down the various steps in CVD process.

5. What is the significance of nanofillers? Give examples.

6. What are biosensors?

7. What is the interpretation of output from UV-visible spectroscopy?

8. Explain the principle of thermogravimetric analysis

9. Give examples of nanomaterials used in catalysis.

10. What are the applications of nanolithography?

PART B

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

Module -I

11. Write a note on pioneers who contributed for the propagation of the ideas of nanotechnology.

12. (a) Describe the classification of nanomaterials.

(b) How surface area and aspect ratio influence the change in properties of nanomaterials?

Module -II

13. What is CVD? Describe the classification of CVD processes. What are the various steps involved in a CVD process?

14. Describe the synthesis, properties and applications of carbon nano tubes.

Module -III

15. Write a note on polymer nanocomposites. Explain the significance of nanofillers citing examples.

16. What is targeted drug delivery? What are the applications of nanomaterials in cancer treatment?

Module -IV

17. Describe the principle and operation of SEM using a ray diagram

18. Discuss on the various characterisation techniques to conduct thermal degradation studies.

Module -V

19. Explain the application of nanomaterials in energy conversion and storage.

20. Describe photolithography using a neat diagram. (14x5 =70)

Syllabus

Module 1 (Introduction and general properties) (9 Hrs.)

Introduction to Nanotechnology - History of nanotechnology, Pioneers in the field of nanotechnology. Classification of nano-materials: Zero, one, two and three dimensional nano-structured materials. Electromagnetic spectrum, particle size and its significance.
Physics of nanomaterials - Size effect on thermal, electrical, electronic, mechanical, optical and magnetic properties of nanomaterials- surface area and aspect ratio- band gap energy- quantum confinement effect.
Chemistry of nanomaterials - Ionic properties of nanomaterials, electronic phenomenon in nanostructures.

Module 2 (Synthesis methods) (10 Hrs.)

Synthesis methods - top down and bottom up approach. Top down approach – size reduction techniques like milling and machining.
Bottom up approach - Sol-gel methods, Chemical vapour deposition, Physical Vapour Deposition, Wet chemical synthesis, Laser ablation methods
Synthesis, properties and applications of nanomaterials like gold, silver and different types of nano-oxides like Al2O3, TiO2, ZnO and SiO2
Special nano-materials - synthesis, properties and applications – fullerenes, graphene, graphite, carbon nano-tubes, nano wires, nano rods, nanofluids, nanoclusters.

Module 3 (Nanocomposites and Bionanotechnology) (8 Hrs.)

Nanocomposites - Matrix materials- Basics of Metal matrix, Ceramic Matrix and Polymer Matrix nanocomposites - Nano-reinforcements, nanofillers- nanoclays. Introduction to bionanotechnology (fundamental concepts only) - Nanomedicine, Drug delivery, Therapeutic applications Applications of biosensors, Future of Bionanotechnology.

Module 4 (Characterisation techniques) (10 Hrs.)

Characterisation techniques - Scanning Electron Microscopy (SEM) - Energy Dispersive X-ray Spectroscopy (EDS) - Transmission Electron Microscopy (TEM) - Atomic Force Microscopy (AFM), Scanning Probe Microscopy (SPM) - Scanning Tunneling Microscopy (STM). UV-visible spectroscopy, Raman spectroscopy, Nuclear Magnetic Resonance Spectroscopy (NMR), Fourier Transform Infrared Spectroscopy (FTIR). X-Ray Diffraction (XRD), Dynamic Light Scattering (DLS)
Thermogravimetric analysis (TGA), Differential Thermal Analysis (DTA), Differential Scanning Calorimetry (DSC)

Module 5 (Applications in energy, catalysis and electronics) (8 Hrs.)

Applications (fundamental concepts only) -: Nanoscale advances in energy and catalysis - Nanotechnology for sustainable energy, nanotechnology enabled renewable energy technologies. Application of nanomaterials in catalysis.

Nanoelectronics - Introduction to Micro Electro Mechanical Systems (MEMS), Nano Electro Mechanical Systems (NEMS)
Nanomanipulation – STM based atomic manipulations, Nanolithography, softlithography, Scanning Probe Lithography, photolithography, E-beam Lithography, Focused ion beam lithography, Dip-pen Lithography

Text Books

1. Joel I. Gersten, ―The Physics and Chemistry of Materials, Wiley, 2001 2. G. Cao, Nanostructures & Nanomaterials: Synthesis, Properties & Applications, Imperial College Press, 2004.
2. S Zhang, L. Li and Ashok Kumar, Materials Characterization Techniques, CRC Press (2008).
3. T. Pradeep, Nano: The Essentials, McGraw-Hill (India) Pvt Limited, 2008.
4. Nanocomposite science and technology, Pulikel M. Ajayan, Wiley-VCH 2005
5. C. M. Niemeyer, C. A. Mirkin, ―Nanobiotechnology: Concepts, Applications and Perspectives, Wiley – VCH, (2004)
6. J. Twidell and T. Weir, Renewable Energy Resources, E & F N Spon Ltd, London, (1986)
7. Nanotechnology in Catalysis Volumes 1 and 2, Bing Zhou, Sophie Hermans, Gabor A. Somorjai , Springer Science & Business Media, 05-Sep-2007
8. W.R.Fahrner, Nanotechnology and Nanoelectronics–Materials, Devices, Measurement Techniques, Springer-Verlag Berlin, Germany (2006).

Reference Books

1. K.W. Kolasinski, ―Surface Science: Foundations of Catalysis and Nanoscience, Wiley, 2002.
2. S. Edelstein and R. C. Cammarata, ―Nanomaterials: Synthesis, Properties and Applications, Institute of Physics Pub., 1998.
3. S.Yang and P.Shen: ―Physics and Chemistry of Nanostructured Materials,Taylor & Francis, 2000.
4. Z L Wang (Ed.), Characterization of Nanophase materials, Willet-VCH (2000).
5. Guo, Jinghua (Ed.), X-rays in Nanoscience - Spectroscopy, Spectromicroscopy, and Scattering Techniques, John Wiley &Sons (2010).
6. Handbook of Nanoscience, Engineering and Technology, Kluwer publishers, 2002.
7. David S Goodsell, "Bionanotechnology, John Wiley & Sons, (2004).
8. Zheng Cui, Nanofabrication, Principles, Capabilities and Limits, Springer Science + business media, New York (2008).

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Introduction and general properties (9 Hrs.)**	
1.1	Introduction to Nanotechnology - History of nanotechnology, Pioneers in the field of nanotechnology.	2
1.2	Classification of nano-materials: Zero, one, two and three dimensional nano-structured materials.	1
1.3	Electromagnetic spectrum, particle size and its significance.	1
1.4	Physics of nanomaterials - Size effect on thermal, electrical, electronic, mechanical, optical and magnetic properties of nanomaterials- surface area and aspect ratio- band gap energy- quantum confinement size effect.	3
1.5	Chemistry of nanomaterials - Ionic properties of nanomaterials, electronic phenomenon in nanostructures.	2
2	**Synthesis methods (10 Hrs.)**	
2.1	Top down approach – size reduction techniques like milling and machining.	1
2.2	Bottom up approach - Sol-gel methods, Chemical vapour deposition, Physical Vapour Deposition, Wet chemical synthesis, Laser ablation methods	3
2.3	Synthesis, properties and applications of nanomaterials like gold, silver and different types of nano-oxides like Al2O3, TiO2, ZnO and SiO_2	2
2.4	Special nano-materials - synthesis, properties and applications – fullerenes, graphene, graphite	2
2.5	synthesis, properties and applications of carbon nano-tubes, nano wires, nano rods, nanofluids, nanoclusters	2
3	Nanocomposites and Bionanotechnology **(8 Hrs.)**	
3.1	Matrix materials- Basics of Metal matrix, Ceramic Matrix nanocomposites	2
3.2	Polymer Matrix nanocomposites - Nano-reinforcements, nanofillers- nanoclays	2
3.3	Introduction to bionanotechnology- Nanomedicine, Drug delivery, Therapeutic applications	2
3.4	Applications of biosensors, Future of Bionanotechnology	2
4	**Characterisation techniques (10 Hrs.)**	
4.1	Scanning Electron Microscopy (SEM) - Energy Dispersive X-ray Spectroscopy (EDS) - Transmission Electron Microscopy (TEM) - Atomic Force Microscopy (AFM), Scanning Probe Microscopy (SPM) - Scanning Tunneling Microscopy (STM)	3
4.2	UV-visible spectroscopy, Raman spectroscopy, Nuclear Magnetic	3

	Resonance Spectroscopy (NMR), Fourier Transform Infrared Spectroscopy (FTIR)	
4.3	X-Ray Diffraction (XRD), Dynamic Light Scattering (DLS)	1
4.4	Thermogravimetric analysis (TGA), Differential Thermal Analysis (DTA), Differential Scanning Calorimetry (DSC)	3
5	**Applications in energy, catalysis and electronics (8 Hrs.)**	
5.1	Applications: Nanotechnology for sustainable energy, nanotechnology enabled renewable energy technologies	2
5.2	Application of nanomaterials in catalysis.	2
5.3	Nanoelectronics - Introduction to Micro Electro Mechanical Systems (MEMS), Nano Electro Mechanical Systems (NEMS)	1
5.4	Nanomanipulation – STM based atomic manipulations, Nanolithography, softlithography, Scanning Probe Lithography, photolithography, E-beam Lithography, Focused ion beam lithography, Dip-pen Lithography	3

SEMESTER VI

HONOURS

CHT394	CHEMICAL REACTION ENGINEERING II	CATEGORY	L	T	P	CREDIT
		VAC	3	1	0	4

Preamble: The objective of this course is to impart and to continue the rigorous study of reaction engineering. In this course, particular emphasis will be given to chemical kinetics, review of elements of reaction kinetics, rate processes in homogeneous and heterogeneous reacting systems, design of ideal and non-ideal reactors, models of non-ideal flow, design of fluid-solid non-catalytic reactions and reactor design.

Prerequisite: CHT 305 Chemical Reaction Engineering.

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

CO 1	Design of ideal reactors for homogeneous systems.
CO 2	Design of chemical reactors for homogeneous systems incorporating non isothermal and non-ideality in the reaction condition.
CO 3	Development of design equations for ideal reactor for heterogeneous systems.
CO 4	Analyse the effect of diffusion process and reaction kinetics in porous catalyst system.
CO 5	Design chemical reactors for fluid particle non catalytic reactions.

Mapping of course outcomes with program outcomes

	PO1	PO2	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									
CO 3	3		3									
CO 4		3	2									
CO 5	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): Design of ideal reactors for homogeneous systems.

1. Derive the performance equation for an ideal batch reactor.
2. Explain integral and differential method of analysing batch reactor data.
3. Compare the performance of plug flow reactors connected in series and parallel.

Course Outcome 2 (CO2): Design of chemical reactors for homogeneous systems incorporating non isothermal and non-ideality in the reaction condition.

1. Derive the expression for conversion for a non isothermal adiabatic reaction starting from the energy balance equation.
2. Explain segregation model in non ideal reactors.
3. Define the terms (i) RTD (ii) Dispersion number and (iii) Variance.

Course Outcome 3(CO3): Development of design equations for ideal reactor for heterogeneous systems.

1. Derive the performance equation of PFR containing porous catalyst particles.
2. Explain the Langmuir- Hinshelwood surface reaction model.
3. Explain the steps involved in a heterogeneous catalytic reaction.

Course Outcome 4 (CO4): Analyse the effect of diffusion process and reaction kinetics in porous catalyst system.

1. Obtain Thiele modulus from the derivation describing diffusion and reaction for $A \rightarrow B$.

2. Define the terms effective diffusivity and tortousity.

3. Differentiate internal effectiveness factor and overall effectiveness factor.

Course Outcome 5 (CO5): Design chemical reactors for fluid particle non catalytic reactions.

1. Explain shrinking core model for particles of unchanging size.

2. A batch of solids of uniform size is treated by gas in a uniform environment. Solid is converted to give a non flaking product according to SCM. The conversion is about 87.5% in a reaction time of 1 hr and conversion is complete in 2 hrs. Determine the rate controlling mechanism.

3. Derive the relationship between time and conversion for solid fluid non catalytic reaction, without change in particle size in which gas film diffusion controls the rate.

Model Question paper

QP CODE: **PAGES: 4**
Reg No:_____
Name :_____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
SIXTH SEMESTER B.TECH DEGREE EXAMINATION,
MONTH & YEAR
Course Code: CHT 394
ADVANCED CHEMICAL REACTION ENGINEERING

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

(2019-Scheme)
PART A
(Answer all questions, each question carries 3 marks)

1. Define an autocatalytic reaction with example.

2. Define space time and space velocity.

3. What are the causes of non ideality in reactors?

4. Differentiate microfluid and macrofluid.

5. Differentiate physisorption and chemisorption.

6. What are the different types of heterogeneous reactions?

7. Define (i) internal effectiveness factor and (ii) overall effectiveness factor.

8. Give the significance of thiele modulus in diffusion and reaction of porous catalyst pellets.

9. Differentiate SCM and PCM.

10. What are the different types of fluid- solid non catalytic reactions?

PART B

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

Module I

11. a. Obtain the conversion for first order reversible reaction A ↔ R which occurs in a batch reactor. 8 marks

b. A PFR of 2 m^3 processes an aqueous feed (100 L/minutes) containing reactant A (C_{A0}=100 mmols/ L). This reaction is reversible A↔ R represented by $-r_A=0.04min^{-1}C_A$- 0.01 $min^{-1}C_R$. First find the equilibrium conversion and then find actual conversion of A in the reactor. 6 marks

12. a. Show that the performance of N equal sized mixed flow reactors in series is equal to a plug flow reactor. Assume first order reaction. 8 marks

b. Compare the performance of plug flow reactors connected in series and parallel.

6 marks

Module II

13. a. Discuss on multiple steady state in an isothermal CSTR. 8 marks

b. From pulse input in to a vessel we obtain the following output signal. Use Tank in series model. Determine the number of tanks.

t, min	1	3	5	7	9	11	13	15
C pulse, g/l	0	0	10	10	10	10	0	0

6 marks

14. a. A Sample of tracer is injected as a pulse to a reactor and following C pulse versus time data is obtained. Tabulate E (t) and F (t) values.

t(min)	0	1	2	3	4	5	6	7	8	9	10	12	14
C (g/m^3)	0	1	5	8	10	8	6	4	3	2.2	1.5	0.6	0

6 marks

b. Explain tank in series model. 8 marks

Module III

15. a. For the reaction $A + B \leftrightarrow C$, the mechanism is given by

$A + S \leftrightarrow A.S$ *Adsorption*

$B + S \leftrightarrow B.S$

$A.S + B.S \leftrightarrow C.S + S$ *Surface Reaction*

$C.S \leftrightarrow C + S$ *Desorption*

Develop the overall rate equation assuming (a) adsorption of A as rate controlling (b) Surface reaction as rate controlling. 9 marks

b. Derive the performance equation of MFR containing porous catalyst particles.

5 marks

16. a. Determine the amount of catalyst needed in a packed bed reactor with a very large recycle rate (assume mixed flow) for 35 % conversion of A to R for a feed rate of 2000mol/hr of pure A at 3.2 atm and 117 ^{0} C. For the reaction at this temperature, A $\rightarrow$4R, $-r_A' = 96\ C_A$, mol/Kg catalyst.hr. 5 marks

b. Develop the rate equation for decomposition of Cumene to form Benzene and Propylene in gas phase.

$C + S \leftrightarrow C.S$ Adsorption of Cumene

$C.S \leftrightarrow B.S + P\ (g)$ Surface reaction to form Benzene and Propylene in gas phase

$B.S \leftrightarrow B + S$ Desorption of Benzene

Develop the overall rate equation assuming (a) Adsorption is controlling. (b) Surface reaction is controlling. 9 marks

Module IV

17. a. Explain (i) Weisz - Prater criterion for internal diffusion and (ii) Mears criterion for external diffusion. 6 marks

b. Obtain Thiele modulus from the derivation describing diffusion and reaction for $A \rightarrow B$. 8 marks

18. a. Explain the terms (i) effective diffusivity (ii) tortuosity and (iii) constriction factor. 6 marks

b. Derive the expressions for internal effectiveness factor for diffusion and reaction in spherical catalyst pellet 8 marks

Module V

19. a. Calculate the time required for complete burning of graphite (Size R_0 =5mm, density =2.28g/cc) in an 8% oxygen stream at 900 ^{0}C and 1 atm. For high gas velocity assume that film diffusion does not offer any resistance to transfer and reaction. Rate constant k″=20 cm/s. 7 marks

b. Explain shrinking core model for particles of changing size. Derive the relationship between time, shrinking particle size and conversion for reaction in which gas film diffusion controls the rate 7 marks

20. a. With a neat sketch of the concentration profiles, compare shrinking core model with progressive conversion model. 6 marks

b. Spherical solid particles containing B is roasted at constant temperature in an oven by a gas A. The solids are converted to give a non flaking solid product according to the shrinking core model. If diffusion through the ash layer controls, derive an expression for the time required for the progression of reaction, time required for complete conversion and fractional conversion. 8 marks

Syllabus

Module 1 (10 Hrs.)

Chemical Reaction Engineering overview- Reaction Kinetics- constant volume and variable volume batch reactor-Ideal reactors design equations- Ideal batch rectors-Steady state mixed flow reactors- steady state plug flow reactors- design of Single and multiple reactions - multiple reactor systems.

Module 2 (8 Hrs.)

Non isothermal effect into the reactor design- Temperature and pressure effects- Heat effects: adiabatic operations and non-adiabatic operations Multiple Steady States in CSTR. Basics of non-ideal flow- Models of non- ideal flow- zero parameter model-segregation

model-One parameter model Compartment models, axial dispersion model, tanks-in-series model- Convection model for laminar flow- Earliness of mixing, segregation and RTD.

Module 3 (10 Hrs.)

Heterogeneous processes. Global rates of reaction. Types of Heterogeneous reactions - Catalysis. General characteristics of catalysis. Physical adsorption and chemisorption. steps in a catalytic reaction, adsorption equilibrium constant, desorption, surface reaction, synthesizing rate law, rate limiting step-Langmuir- Hinshelwood approach. Development of design equations for ideal mixed batch reactor, plug flow tubular reactor and perfectly mixed continuous stirred tank reactor for heterogeneous systems. Heterogeneous data analysis for reactor design.

Module 4 (8 Hrs.)

Diffusion and reaction in porous catalysts- effective diffusivity, tortuosity-modelling of diffusion with reaction on a spherical catalysts. Thiele Modulus, internal effectiveness factor, Overall effectiveness factor. Estimation of diffusion and reaction limited regimes - Weisz - Prater criterion for internal diffusion, Mears criterion for external diffusion- Mass transfer and reaction in a packed bed.

Module 5 (9 Hrs.)

Fluid Particle Non catalytic Reactions kinetics-Selection of a model-Unreacted core model for spherical particles of unchanging size, model development for diffusion through gas film, ash layer, and chemical reaction controls. Rate of reaction for shrinking spherical particles - chemical reaction controls, diffusion controls, Determination of the rate-controlling step- Fluid Particle reactor design

Text Books

1. Levenspiel Octave , “Chemical Reaction Engineering”, John Wiley & Sons, Third Edition,.
2. H Scott Fogler, “Elements of Chemical Reaction Engineering”, Prentice Hall of India, Fifth Edition.
3. Smith J.M, “Chemical Engineering Kinetics,” McGraw Hill.

Reference Books

1. James J Carberry, “Chemical &Catalytic Reaction Engineering”, Mc Graw Hill.
2. K.G Denbigh& J.C.R Turner, “Chemical Reactor Theory- An Introduction”, Cambridge University Press.
3. Lanny D Schmidt, “The Engineering of Chemical Reactions”, Oxford University Press.
4. Ronald W. Missen, Charles A. Mims, Bradley A. Saville, „Introduction to Chemical Reaction Engineering and Kinetics“, John Wiley & Sons
5. Hill C.G., An Introduction to Chemical Engineering Kinetics & Reactor Design, John Wiley

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Module I (10 Hrs.)**	
1.1	Chemical Reaction Engineering overview	1
1.2	Reaction Kinetics- constant volume rectors	2
1.3	Reaction Kinetics- variable volume rectors	1
1.4	Ideal reactors design equations- Ideal batch rector	1
1.5	Ideal reactors design equations -Steady state mixed flow reactors	1
1.6	Ideal reactors design equations- steady state plug flow reactors	1
1.7	Design of Single and multiple reactions -multiple reactor systems.	3
2	**Module II (8 Hrs.)**	
2.1	Non isothermal effect into the reactor design- Temperature and pressure effects	1
2.2	Heat effects: adiabatic operations and non-adiabatic operations Multiple Steady States in CSTR.	1
2.3	Basics of non-ideal flow	1
2.4	Models of non-ideal flow- zero parameter model Segregation model-One parameter model	1
2.5	Compartment model and axial dispersion model	2
2.6	Tanks-in-series model and Convection model for laminar flow	1
2.7	Earliness of mixing, segregation and RTD	1
3	**Module III (10 Hrs.)**	
3.1	Heterogeneous processes. Global rates of reaction. Types of Heterogeneous reactions	1
3.2	Catalysis. General characteristics of catalysis. Physical adsorption and chemisorption. steps in a catalytic reaction	2
3.3	Adsorption equilibrium constant, desorption, surface reaction,	2
3.4	Synthesizing rate law, rate limiting step-Langmuir- Hinshelwood approach.	2
3.5	Development of design equations for ideal mixed batch reactor, plug flow tubular reactor and perfectly mixed continuous stirred tank reactor for heterogeneous systems.	2
3.6	Heterogeneous data analysis for reactor design.	1
4	**Module IV (8 Hrs.)**	
4.1	Diffusion and reaction in porous catalysts- effective diffusivity, tortuosity	1
4.2	Modelling of diffusion with reaction on a spherical catalysts.	1
4.3	Thiele Modulus, internal effectiveness factor, Overall	2

	effectiveness factor.	
4.4	Estimation of diffusion and reaction limited regimes - Weisz - Prater criterion for internal diffusion	2
4.5	Mears criterion for external diffusion- Mass transfer and reaction in a packed bed.	2
5	**Module V (9 Hrs.)**	
5.1	Fluid Particle Non catalytic Reactions kinetics	1
5.2	Selection of a model -Unreacted core model for spherical particles of unchanging size	2
5.3	Model development for diffusion through gas film, ash layer, and chemical reaction controls.	2
5.4	Rate of reaction for shrinking spherical particles - chemical reaction controls, diffusion controls,	1
5.5	Determination of the rate-controlling step.	1
5.6	Fluid Particle reactor design	2

CHT396	ADVANCED WASTE WATER TREATMENT TECHNIQUES	CATEGORY	L	T	P	CREDIT
		VAC	3	1	0	4

Preamble: This subject aims to give knowledge to the students regarding advanced wastewater treatment technologies. It details primary, secondary, tertiary and advanced methods of treatments of waste water and the sludge disposal techniques. Also, it covers the methodology for treating the effluents from different industries and helps to understand the regulatory standards of treated effluents from various industries and the Legislations.

Prerequisite : Knowledge of physical, chemical and biological treatment of wastewater

Course Outcomes:

After the completion of the course the student will be able to

CO 1	Identify the Environmental problems and the regulatory requirements for treatment and disposal of waste water.
CO 2	Analyse conventional biological treatment methods
CO 3	Apply advanced technologies in Wastewater treatment
CO 4	Explain different types of electrochemical treatment options for wastewater treatment.
CO5	Select treatment options for different types of industrial effluent.

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					
CO 3	3						3					
CO 4	3						3					
CO 5	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): Identify the Environmental problems and the regulatory requirements for treatment and disposal of waste water.

1. Explain the Characteristics of Wastewater from different sources.
2. List the environmental consequences of wastewater discharge
3. List the Regulation or Legislation in Water Pollution.

Course Outcome 2 (CO2): Analyse conventional biological treatment methods

1. Explain the microorganism involved biological processes.
2. Derive basic equation for the activated sludge process.
3. Discuss about the nitrogen removal processes in wastewater treatment

Course Outcome 3(CO3): Apply advanced technologies in wastewater treatment

1. Describe the Filtration and membrane separation techniques in wastewater treatment.
2. Explain the ion exchange processes.
3. Discuss about various types of membrane seperation processes used in wastewater treatment.

Course Outcome 4 (CO4): Explain different types of electrochemical treatment options for wastewater treatment.

1. List out the various reactor configurations used in electrocoagulation.
2. Explain the functioning of electro floatation process.
3. Discuss the theory of advanced oxidation.

Course Outcome 5 (CO 5): Select treatment options for different types of industrial effluent..

1. Propose a treatment scheme for treating sugar industry effluent.
2. Explain the methods adopted to remove oil and grease from wastewater.
3. Propose a treatment scheme to treat tannery industry effluent.

MODEL QUESTION PAPER

PAGES:

Reg No:_____ Name :_____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SIXTH SEMESTER B. TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: CHT 396

Max. Marks: 100 Duration: 3 Hours

ADVANCED WASTE WATER TREATMENT TECHNIQUES

PART A

(Answer all questions, Each carry 3 marks)

1. List the environmental legislations prevails in India?
2. Write the classification of wastewater treatment methods.
3. Distinguish the neutralisation and equalisation processes.
4. Briefly describe the oxygen requirement in aerobic process
5. Write the principle of reverse osmosis.
6. List out the different types of membranes used in wastewater treatment
7. Discuss about the commonly used electode material in electrochemical treatment of wastewater?
8. Explain the working of solar photo catalytic treatment systems?
9. Explain the common Operational problems encountered in treatment plants
10. Write Sources, Characteristics of effluent from a fertilizer industry.

(10 X3= 30 Marks)

PART B

(Answer any one full question from each Module)

MODULE I

11. a) What are the Environmental consequences of wastewater discharge from Thermal power plants?
    b) Explain the characteristics of waste water.

OR

12. Explain the Environmental consequences of wastewater discharge and the regulatory requirements for treatment and disposal of waste water.

MODULE II

13. Describe ASP. Starting from the material balance derive the expression for HRT and SRT for an ASP?

OR

14. Write a note on;
    1. Aerated lagoons
    2. Oxidation ditches
    3. UASB

MODULE III

15. a) List out the resin commonly used in ion exchange process.
    b) Explain Cationic and anionic exchange process.

OR

16. Discuss about various membrane seperation methods used for wastewater treatment

MODULE IV

17. Explain the various electrochemical treatment methods used in wastewater treatment

OR

18. Discuss in detail about advanced oxidation processes.

MODULE V

19. Explain the Characteristics, methodology and process for the treatment of effluent from beverage industry.

OR

20. Develop a flow sheet for the treatment of effluents from Sugar industry. And explain all Processes. Explain the typical problem arising in various units.

(5 X14= 70 Marks)

****

SYLLABUS

MODULE I (4 Hrs.):

Water Pollution and Treatment: Advanced Wastewater Treatment: Need and purpose of Advanced WWT: Characteristics of wastewater – Physical, Chemical and Biological. Environmental consequences of wastewater discharge and the regulatory requirements for treatment and disposal treatment levels and available technologies. Legislations.

MODULE II (13 Hrs.)

Wastewater Treatment: Primary treatment: Screening, Grit removal, Neutralization, equalization, Sedimentation, Flotation (oil & grease removal), Air stripping Secondary treatment: principles of waste treatment, basic kinetic equation, continuous flow treatment models, oxygen requirement in aerobic process, production of sludge. Conventional biological process: Activated Sludge Process (ASP)- development of material balance equations, UASB and Trickling Filters. Biological waste treatment: RBC, Nitrogen removal: Nitrification and denitrification process, phosphorous removal, tube aeration system, anaerobic filters. Low cost wastewater treatment: Aerated lagoons, stabilization ponds, oxidation ditches.

MODULE III (10 Hrs.)

Advanced Treatment Options: Tertiary treatment – ion exchange, Membrane separation Techniques: Brief description of MF, UF, NF membranes. Reverse osmosis principle, Membrane materials, Types of membranes – Plate & frame, tubular, hollow fibre, spiral wound membranes. Evaporators: forces evaporation, Multiple effect evaporators – falling film, raising film, forced circulation, agitated thin film driers.

MODULE IV (10 Hrs.)

Electrochemical Wastewater Treatment Processes: Introduction, Electro-coagulation : Factors affecting Electrocoagulation, Electrode materials , Reactor configurations. Electro-floatation : Factors affecting electro floatation, Comparison with other technology, Reactor configurations, Electro-oxidation : Electro oxidation process, Reactor configurations.

Advanced Oxidation Processes: Theory of advanced oxidation, Types of oxidizing agents, ozone based and non- ozone based processes, Fenton and photo-Fenton Oxidation. Solar Photo Catalytic Treatment Systems.

MODULE V (8 Hrs.)

Industrial Wastewater Treatment: Sources, Characteristics, methodology and process for the treatment of industrial wastes of sugar industry- beverage industry – tannery industry – textile mill waste industry – fertilizer plant – steel plant – oil refinery – paper and pulp mill. Sources, Characteristics, methodology and process for the treatment of Municipal waste water. Operational problems encountered in treatment plants: typical problems arising in various units, trouble shooting. Cleaner technologies: Water conservation.

Reference books

1. Weber, W.J. and DiGiano, F.A. “Process Dynamics in Environmental Systems”. Wiley Interscience. ISBN: 0471017116
2. McCarty, P., and Rittmann, B., “Environmental Biotechnology: Principles and Applications”, McGraw Hill, 2000. ISBN: 0072345535
3. Mark.J.Hammer & Mark.J.Hammer Jr., Water and Wastewater Technology, Prentice Hall of India. Ltd.

Text books: -

1. Metcalf & Eddy, “Wastewater Engineering – Treatment and Reuse”, Revised by G.Tchobanoglous, F. L. Burton, and H. D. Stensel, 4th edition. Tata McGraw-Hill, 2003.
2. Casey, T.J., “Unit Processes in Water and Wastewater Engineering”. Wiley Interscience, 1997. ISBN: 0471966932
3. W.W. Eckenfelder, “Industrial Water Pollution Control”, Mc-Graw Hill, 1999

Course content and lecture schedule

No	Topic	No. of Lectures
1	**MODULE I- Water Pollution and Treatment (4 Hrs.)**	
1.1	Introduction on waste water treatment, Types of Sources, quality of water, Characteristics of waste water.	1
1.2	Various stages of Waste Water treatment process: aeration, Sedimentation, Filtration: slow and rapid sand filters.	1
1.3	Environmental consequences of wastewater discharge and the regulatory requirements for treatment and disposal treatment levels and available technologies. Legislations.	2
2	**MODULE 2- Wastewater Treatment (13 Hrs.)**	
2.1	Characteristics of waste water and treatment plant effluents, Dissolved oxygen.	1
2.2	Primary treatment: Screening, Grit removal, Neutralization, equalization, Sedimentation, Flotation (oil & grease removal)	2
2.3	Air stripping Secondary treatment: principles of waste treatment, basic kinetic equation, continuous flow treatment models, oxygen requirement in aerobic process, production of sludge.	2
2.4	Conventional biological process: Activated Sludge Process (ASP), UASB and Trickling Filters.	1
2.5	Biological waste treatment: RBC, Nitrogen removal: Nitrification and denitrification process, Phosphorus removal by Chemical Precipitation: Principles of process, Chemicals applied, Chemistry of phosphorus precipitation, Process configuration, Phosphorus removal by Biological Precipitation: Principles of the process, Microorganisms involved in the process, Process configurations	3
2.6	Utube aeration system, anaerobic filters.	2
2.7	Low cost wastewater treatment: Aerated lagoons, stabilization ponds, oxidation ditches	2
3	**MODULE 3- Advanced Treatment Options (10 Hrs.)**	
3.1	Tertiary treatment – ion exchange -Fundamentals of Ion Exchange, Types of Ion Exchange, Resins Theory of Ion Exchange, Applications: Removal and recovery of heavy metals, Removal of nitrogen , Removal of phosphorus , Organic chemical removal	3
3.2	Membrane separation Techniques: Brief description of MF, UF, NF membranes. Reverse osmosis principle, Membrane materials, Types of membranes – Plate & frame, tubular, hollow fibre, spiral wound membranes, application of membranes in various industrial applications.	3

3.3	Electro chemical techniques: electro dialysis, electro coagulation, Factors affecting Electrocoagulation, Electro-floatation : Factors affecting electro floatation Comparison with other technology, Reactor configurations Electro-oxidation : Electro oxidation process, Reactor configurations	2
3.4	Evaporators: forces evaporation, Multiple effect evaporators – falling film, raising film, forced circulation, agitated thin film driers.	2
3.5	Advanced oxidation processes, photo catalysis.- Theory of advanced oxidation, Types of oxidizing agents, ozone based and non-ozone based processes Fenton and photo-Fenton Oxidation Solar Photo Catalytic Treatment Systems	2
4	**MODULE 4- Electrochemical Wastewater Treatment Processes (10 Hrs.)**	
4.1	Introduction, importance of sewage, Characteristics of sewage, Sampling and analysis of sewage.	1
4.2	Sewage treatment and disposal: Skimming, Grit chamber, Sedimentation tanks, Septic tank.	2
4.3	Secondary treatment-types of filters, rate of filter loading, Activated sludge process, sludge digestion, Sludge disposal.	3
5	**MODULE 5- Industrial Wastewater Treatment (8 Hrs.)**	
5.1	Sources, Characteristics, methodology and process for the treatment of industrial wastes of sugar industry- beverage industry – tannery industry – textile mill waste industry – fertilizer plant – steel plant – oil refinery – paper and pulp mill.	5
5.2	Sources, Characteristics, methodology and process for the treatment of Municipal waste water.	1
5.3	Operational problems encountered in treatment plants: typical problems arising in various units, trouble shooting.	1
5.4	Cleaner technologies: Water conservation.	1

CHT 398	MODERN CONTROL THEORY	CATEGORY	L	T	P	CREDIT
		VAC	3	1	0	4

Preamble : The aim of the subject is to develop the methods of representation of systems and their transfer function models. To provide adequate knowledge in the time response of systems and steady state error analysis. To accord basic knowledge in obtaining the open loop andclosed–loop frequency responses of systems. To understand the concept of stability of control system and methods of stability analysis.

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

CO 1	Solve numerical problems on state space theorem
CO 2	Prove Cayley-Hamilton theorem
CO 3	Develop solutions of state equations.
CO 4	Define stability and find stability analysis using Liapunov theorm.
CO 5	Find stability of nonlinear systems using Krasovski method and variable gradient method.

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							3	
CO 2	3	3	3	3							3	
CO 3	3	3	3	3							3	
CO 4	3	3	3	3							3	
CO 5	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. Obtain the state model of the system whose transfer function is given .

2. Explain the basic elements of a state diagram?.

3. Explain state vector, input vector, output vector.

Course Outcome 2 (CO2)

1. State and prove Cayley Hamilton theorem

2. Explain Quadratic forms and sign definiteness of Quadratic forms .

3. Find the state transition matrix of any 3x3 matrix.

Course Outcome 3(CO3):

1. Obtain the time response of the system :

$$\begin{bmatrix}\dot{x}_1\\ \dot{x}_2\end{bmatrix} = \begin{bmatrix}0 & 3\\ -2 & -5\end{bmatrix}\begin{bmatrix}x_1\\ x_2\end{bmatrix} + \begin{bmatrix}0\\ 2\end{bmatrix}u$$

Where u (t) is the unit step function occurring at t=0

2. Find the transfer function of the system whose governing equations are as given.

3. Derive any one method of solution of non homogeneous state equations.

Course Outcome 4 (CO4):

1. Explain stability, asymptotic stability and instability using suitable physical models.

2. State and explain the Lyapunov stability theorems.

3. Derive transfer function of a system from its state model

Course Outcome 5 (CO5):

1. Give the procedure to get a Lyapunov function using variable gradient method.

2. Use the variable gradient method to investigate the stability of equilibrium state of a nonlinear system

3. Explain Controllability and Observability .

Model Question paper

Name :

Reg no :

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
SIXTH SEMESTER B.TECH. DEGREE EXAMINATION,MONTH AND YEAR

Course code CHT 398

Time : 3 hours **Max. Marks: 100**

Modern control Theory

(2019 Scheme)

Part A

(Answer all questions. All questions carry three marks.)

1. What are state variables and equilibrium form?
2. What is Bush form?
3. What is inverse of matrix?
4. What is state transition matrix?
5. Explain state space representation.
6. What is transfer matrix?
7. What are discrete systems?
8. Define Liapunov stability theorem.
9. Define Controllability.
10. Define Observability.

Part B

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

Q.no.	Module 1	Marks
1a	Obtain canonical state model of the system whose transfer function is $\frac{S+5}{(S+1)(S+2)(S+3)}$	7
1b	Explain the basic elements of a state diagram? Draw the block diagram of the system described by state model, $\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{bmatrix} = \begin{bmatrix} a_1 & a_2 & 0 \\ 1 & 0 & 1 \\ 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 1 \\ 0 \\ 0 \end{bmatrix} u; y = x_3$	7
	OR	
2a	Derive the state space representation of the system described the differential equation $\dddot{y} + 5\dot{y} + 4y = u$ and obtain suitable transformation to get the diagonalisation. Also write the new state representation.	7
2b	Find the Eigen values, Eigen vectors and Jordan form representation of the following matrix. $\begin{bmatrix} 4 & 1 & -2 \\ 1 & 0 & 2 \\ 1 & -1 & 3 \end{bmatrix}$	7

Q.no.	Module 2	Marks
3	State and prove Cayley Hamilton theorem and Explain Quadratic forms and sign definiteness of Quadratic forms	14
	OR	
4a	Compute the state transition matrix of the system $\frac{dx}{dt} = Ax, where\ A = \begin{bmatrix} -3 & 1 & 0 \\ 0 & -3 & 1 \\ 0 & 0 & -2 \end{bmatrix}$ With the use of the Laplace transform.	7
4b	Find f(A)=A^{10} for $A = \begin{bmatrix} 0 & 1 \\ -1 & -2 \end{bmatrix}$	7

Q.no.	Module 3	Marks

5a A system has the system matrix A as given below: **7**

$$A = \begin{bmatrix} 2 & -1 & 1 \\ 1 & 1 & -1 \\ 1 & 3 & 1 \end{bmatrix}$$

Find the unforced solution of the system if initial condition is given by $x(0) = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}$

5b Derive any one method of solution of non homogeneous state equations? **7**

OR

6a Obtain the time response of the system : **7**

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 0 & 3 \\ -2 & -5 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0 \\ 2 \end{bmatrix} u$$

Where u (t) is the unit step function occurring at t=0.

6b Find the transfer function of the system whose governing equations are as given below: **7**

$$\dot{x}_1 = -4x_1 - x_2 + 3u$$

$$\dot{x}_2 = -2x_1 - 3x_2 + 5u, y = x_1 + 2x_2$$

Q.no.	Module 4	Marks

7a Define stability, asymptotic stability and instability in the sense of Liapunov. (Use suitable figures) **7**

7b A discrete time system has the transfer function $\frac{Y(z)}{U(z)} = \frac{4z^3 - 12z^2 + 13z - 7}{(z-1)^2(z-2)}$ **7**

.Determine the state model of the system in Jordan Canonical form.

OR

8a Derive transfer function of a system from its state model: **7**

$$x(k+1) = Ax(k) + Bu(k)$$

$$y(k) = Cx(k) + Du(k)$$

8b A discrete time system has state equation given by **7**

$$x(k+1) = \begin{bmatrix} -6 & 2 \\ -6 & 1 \end{bmatrix} x(k)$$

Use Cayley Hamilton approach to find out the state transition matrix.

Q.no.	Module 5	Marks
9a	Use the variable gradient method to investigate the stability of equilibrium state of a nonlinear system described by the equations $\dot{x_1} = -x_1 + 2x_1^2 x_2$ $\dot{x_2} = -x_2$	7
9b	Choose a quadratic scalar form and determine the stability of the system described by $\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -3 & -4 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$	7
	OR	
10a	Give the procedure to get a Liapunov function using variable gradient method.	7
10b	Consider the nonlinear system $\dot{x_1} = -x_1 - {x_2}^2$ $\dot{x_2} = -x_2$ Find a region of asymptotic stability using Krasovski method.	7

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
KTU
Estd. 2014

Syllabus

Module 1 (9 Hrs.)

Introduction to state space analysis-Definitions of state space, state variables and equilibrium points-representations of systems described by differential equations and transfer functions in state variable form-Bush form, Canonical form, Jordans form

Module 2 (9 Hrs.)

Cayley-Hamilton theorem- Evaluation of Matrix polynomial, inverse of a matrix, state transition matrix . Quadratic forms and sign definiteness of quadratic forms State space analysis of control systems.

Module 3 (8Hrs.)

Solution of the time invariant state equations-state transition matrix. Transfer matrix. Linear time varying systems.

Module 4 (9 Hrs.)

Discrete systems-state space representation and solution. Liapunov stability analysis- Definition of stability, instability and asymptotic stability. Liapunov stability theorems.

Module 5 (10 Hrs.)

Stability analysis of simple linear systems. Stability analysis of non-linear systems-Krasovski method and variable gradient method. Controllability and Observability-Definitions

Text Books

1. Katsuhiko Ogata, *Modern control engineering*, Prentice- Hall of India, Fifth edition 2015.

2. Chen,C.F and I.J Haas, *Elements of control system analysis*, Prentice Hall, First edition 1968

Reference Books

1. Katsuhiko Ogata, *State space analysis of control systems*, Prentice hall, First edition 1967

2. Kuo,B.C, *Analysis and synthesis of sampled data control systems*, Prentice Hall, First edition 1963

3. A.Nagoor Kani, *Advanced Control Theory*, RBA Publications. Second edition 1999

4. A K Jairath, *Modern Control Theory*, Ane books, Second edition, 2015

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**State space analysis (9 Hrs.)**	
1.1	Introduction to state space analysis	1
1.2	Definitions of state space, state variables and equilibrium points	1
1.3	Representations of systems described by differential equations and transfer functions in state variable form	1
1.4	Bush form	2
1.5	Canonical form	2
1.6	Jordan form	2
2	**Matrix calculations. (9 Hrs.)**	
2.1	Cayley-Hamilton theorem	2
2.2	Evaluation of Matrix polynomial	1
2.3	Inverse of a matrix, state transition matrix	2
2.4	Quadratic forms and sign definiteness of quadratic forms	2
2.5	State space analysis of control systems	2
3	**State space concept. (8Hrs.)**	
3.1	Solution of the time invariant state equations	2
3.2	State transition matrix	2
3.3	Transfer matrix	2
3.4	Linear time varying systems	2
4	**Stability analysis. (9 Hrs.)**	
4.1	Discrete systems-state space representation and solution.	2
4.2	Liapunov stability analysis-	1
4.3	Definition of stability, instability and asymptotic stability.	3
4.4	Liapunov stability theorems.	3
5	**Applications. (10 Hrs.)**	
5.1	Stability analysis of simple linear systems	2
5.2	Stability analysis of non-linear systems-	2
5.3	Krasovski method	2
5.4	Variable gradient method. Controllability and Observability- Definitions	2
5.5	Controllability and Observability- Definitions	2