SEMESTER VII

CHT401	CHEMICAL PROCESS EQUIPMENT DESIGN I	CATEGORY	L	T	P	CREDIT
		PCC	2	1	0	3

Preamble: The objective of this course is to give a foundation for the undergraduates in the design of equipment used in process industries for the unit operations heat transfer, evaporation and evaporative cooling. This course includes sizing of equipment and selection of the internal parts. It also covers the use of standards and codes for the design of equipment.

Prerequisite: Knowledge in heat and mass transfer, process calculations, fluid and particle mechanics, thermodynamics and material science

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

CO 1	Develop the thermal design of double pipe exchangers for a given heat exchange operation between single-component fluids
CO 2	Develop the thermal design of shell and tube exchangers for a given heat exchange operation between single-component fluids
CO 3	Design tubular condensers for condensation of single-component fluids
CO 4	Develop the process design of evaporators for a given feed solution and terminal conditions
CO 5	Design mechanical draft cooling tower for a given tower fill

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

Assessment Pattern

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination**
	1	**2**	
Remember			
Understand			
Apply	50	50	100
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.

- Question paper contains 2 numerical design questions from each module on different topics of which the student shall have to answer any one from each module. Each question carries 50 marks. There can be subdivisions for the main question/topic only.
- The questions should be clear in respect of type of equipment and its alignment if any, operating conditions, and materials handled. Data required for design such as equilibrium data and physical properties in case it cannot be obtained from handbook, material of construction etc shall be provided with the question.
- Question paper should contain instruction as given below:
  Apart from scientific calculators (including programmable) the following books and data books are permitted for the exam:

1. Steam tables
2. Perry's Handbook
3. Dühring's charts, Nomographs, charts and tables used in design taken from TEMA standard/other editions of Handbook. The copies should be attested by the course faculty concerned or as directed by university.

Course Level Assessment Questions

Course Outcome 1 (CO1): *Do thermal design of double pipe exchangers, tubular exchangers and condensers for a given heat exchange operation between single component fluids*

1. Design a double pipe heat exchanger to cool 3600 kg/hr ethanol from 80°C to 40°C using cooling water enters the heat exchanger at 20°C and leaves at 26°C. A fouling factor of $0.0003\ \frac{m^2K}{W}$ should be provided for each stream, and allowable pressure drop on each stream is 10 psi. The heat exchanger consists of 20 ft hairpins of 2 x 1.25 in. Schedule number 40S steel pipes.

Course Outcome 2 (CO2) *Develop the thermal design of shell and tube exchangers for a given heat exchange operation between single-component fluids*

1. A counterflow 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. Estimate the size of the exchanger for a design heat load of 10 kW.
2. 24,000 kg/hr of ethylene glycol is to be cooled from 90 ^{0}C to 40 ^{0}C by water available at 20 ^{0}C. The maximum temperature to which water can be heated is 35 ^{0}C. A 1-2 shell and tube heat exchanger is to be designed for this purpose using 19mm OD 10 BWG steel tubes. Design the exchanger if the length of the tube is limited to 4 m. Fouling resistance and wall resistance can be neglected.

Properties of fluids at mean temperatures are:

Property	*Ethylene glycol*	*Water*
Density, kg/m^3	1078	995
Viscosity, Ns/m^2	3.22 x10^{-3}	0.853 x 10^{-3}
Specific heat, J/kg K	2650	4180
Thermal conductivity, W/mK	0.261	0.614

Course Outcome 3 (CO3): *Design tubular condensers for condensation of single-component fluids*

3. 5000 kg/hr of propanol is to be condensed in a shell and tube condenser at 1atm pressure. Cooling water is circulated in tubes with inlet temperature 20^{0}C and outlet temperature 30^{o}C. Design a vertical condenser

Course Outcome 4 (CO4): *Develop the process design of evaporators for a given feed solution and terminal conditions*

4. Design a single effect short tube vertical evaporator to concentrate 5000 kg/hr of 2% NaOH solution by weight, available at 25^{o}C to a concentration of 20% NaOH by weight. Saturated steam is available at 1.5 kgf/cm^2 (abs). The pressure in the evaporator is 70 cm of Hg. Boiling point elevation of the solution is 6^{0}C. Enthalpy of feed and thick liquor is 18kcal/kg and 80kcal/kg respectively. The cross sectional area of the down comer should be approximately 50% of the total tube flow area. Draw to a suitable scale.

5. A double effect short tube vertical evaporator is used for concentrating 20000 kg/h of 5% sugar solution to 40% using saturated steam available at 3.8 atm absolute. The feed is at 30^{0}C and a vacuum of 600 mm Hg is maintained in the evaporator. For the 1st and 2nd effects, the corrected heat transfer coefficients are 2000 and 1200 W/m^2 ^{0}C respectively and boiling point elevations are 7 and 5^{o}C respectively. Estimate the size of the evaporator and

prepare a data sheet indicating the fluids handled, operating conditions, heat duty, steam flow rate, economy, heat transfer area, calandria details and vapor drum details.

Course Outcome 5 (CO5): *Design mechanical draft cooling tower for a given tower fill*

6. Water at 40°C is to be cooled to 25°C by means of air in an induced draft cooling tower. Water flows at a rate of 2.5 m^3/s. Air is at DBT 30°C with a relative humidity of 70%.

Fill mass transfer coefficient, $K_x.a$: 2 s^{-1}

Properties of air and water are:

Density of air: 1.21 kg/m^3

Specific heat of air: 1005 J/kgK

Specific heat of water vapour: 1884 J/kgK

Latent heat of vaporization: 2334.7 kJ/kg

Estimate the size of tower required for this cooling operation, fan hp for 90% performance and calculate the makeup water required if blow down is once in three cycles.

Draw a neat sketch of the tower sectional elevation to a suitable scale

Model Question Paper

QP CODE: PAGES: 2

Reg No:________________________

Name :_________________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SEVENTH SEMESTER B. TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: CHT 401

Max Duration: 3 Hours Marks:100

CHEMICAL PROCESS EQUIPMENT DESIGN I

(2019 Scheme)

Instructions:

Apart from scientific calculators (including programmable) the following books and databooks are permitted for the exam:

1. *Steam tables*
2. *Perry's Handbook*
3. *Attested copies of Dühring's charts, Nomographs, charts and data tables used in design taken from TEMA standard/ Other editions of Handbook*

(Answer **one full question** from each module; each full question carries 50 marks)

Module -I

1. Design a double pipe heat exchanger to cool 2700 kg/hr ethanol from 80°C to 40°C using cooling water enters the heat exchanger at 20°C and leaves at 26°C. A fouling factor of 0.0003 $\frac{m^2K}{W}$0.0003 $\frac{m^2K}{W}$ should be provided for each stream, and allowable pressure drop on each stream is 10 psi. The heat exchanger consists of 20 ft hairpins of 2 by 1.25 in. Schedule number 40 steel pipes. (50marks)

OR

2. 5000 kg/hr of saturated iso-propyl alcohol is to be condensed in a shell and tube condenser at 1atm pressure. Cooling water is available for circulation in tubes with inlet temperature 20^{o}C and maximum outlet temperature 30^{o}C. Design a horizontal condenser. (50marks)

Module -II

3. A double effect long tube falling film evaporator is used for concentrating 15000 kg/h of 10% sucrose solution to 50% using low pressure steam available at 1.8 atm absolute. The feed is at 30^{o}C and a vacuum of 630 mm Hg is maintained in the evaporator. The corrected heat transfer coefficients are 2000 and 1200 W/m^2 ^{o}C respectively for 1st and 2nd effect and boiling point elevation are 7 and 5^{o}C. Design a long tube falling film evaporator. (50 marks)

OR

4. A paper mill producing 200 tons of pulp per day by the magnesium sulphite process concentrates a 10% waste liquor to 50% in a triple effect forward feed evaporator unit. The solution entering in the first effect at 56^{o}C is evaporated by 40 psig saturated steam. The last effect vapour space is at 26 inch Hg. Boiling point rise in the effects are 10, 8, 5 ^{o}C respectively. Mean specific heat of solution at all concentrations may be taken as 3.65 kJ/kg^{o}C. The overall heat transfer coefficients in the first, second and third evaporators are 1200, 1080, 975 W/m^{2}K respectively. Estimate the heat transfer area and design a rising film evaporator. (50 marks)

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Syllabus

Module 1

Thermal design of double pipe heat exchanger: Constructional features - Calculation of heat transfer area – estimation of heat transfer coefficient – calculation of the size of double pipe – pressure drop estimation in double pipe flow.

Thermal design of shell and tube heat exchanger: Constructional features – baffles and pass partition – TEMA nomenclature – routing of fluids - Calculation of heat transfer area – estimation of tube bundle size - estimation of overall heat transfer coefficient using Bell's method – pressure drop in shell side and tube side.

Thermal design of shell and tube condensers for single component isothermal condensation of saturated vapours in shell. Estimation of heat transfer area – Estimation of bundle size and shell diameter - estimation of in-shell condensation coefficients using Dukler charts – estimation of overall heat transfer coefficient

Module 2

Thermal design of evaporators: Constructional features and design of short tube calandria evaporator, long tube evaporator, and forced circulation evaporator – estimation of heat transfer area in multiple effect evaporators with negligible boiling point rise (double/triple effect forward feed only) – effect of boiling point elevation in evaporator calculation

Process design of mechanical draft Cooling Towers: Estimation of air quantity, tower characteristics - number of diffusion units using graphical method, water concentration, tower cross section area, fan hp, make-up water requirement

Reference Books, codes and standards

1. Perry. R.H & Green.D.W., Chemical Engineers Handbook, Mc- Graw Hill.
2. Kern D.Q., Process Heat Transfer, Tata McGraw Hill.
3. Badger & Bancharo, Introduction to Chemical Engineering, McGraw Hill
4. Coulson J.M.& Richardson J.F., Chemical Engineering, Vol.6, 3rd Edn, Butterworth Heinemann, (Indian print)
5. M.V Joshi & Mahajan V.V., Process Equipment Design, 3rd Edn, Mac-Milan & Co. India.
6. Datta B.K., Heat Transfer: Principles and Applications, Prentice Hall India.
7. McCabe W.L., Smith J.C. & Harriott P., Unit Operations in Chemical Engineering, McGraw Hill.
8. E. Ludwig, Applied Process Design for Chemical & Petrochemical Plants, Vol I, II, III, Gulf Publication, London
9. Standards of Tubular Exchanger Manufacturers Association

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**MODULE-I**	**18**
1.1	Thermal design of double pipe heat exchanger: Constructional features - Calculation of heat transfer area – estimation of heat transfer coefficient	3
1.2	Thermal design of double pipe heat exchanger: calculation of the size of double pipe	2
1.3	Thermal design of double pipe heat exchanger: pressure drop estimation in double pipe flow.	1
1.4	Thermal design of shell and tube heat exchanger: Constructional features – baffles and pass partition – TEMA nomenclature	1
1.5	Thermal design of shell and tube heat exchanger: routing of fluids - Calculation of heat transfer area – estimation of tube bundle size	2
1.6	Thermal design of shell and tube heat exchanger: estimation of overall heat transfer coefficient using Bell's method	2
1.7	Thermal design of shell and tube heat exchanger: pressure drop in shell side and tube side	2
1.8	Thermal design of shell and tube condensers for single component isothermal condensation of saturated vapours in shell. Estimation of heat transfer area	2
1.9	Thermal design of shell and tube condensers for single component isothermal condensation of saturated vapours in shell. Estimation of bundle size and shell diameter - estimation of in-shell condensation coefficients using Dukler charts – estimation of overall heat transfer coefficient	3
2	**MODULE-II**	**17**
2.1	Thermal design of evaporators: Constructional features and design of short tube calandria evaporator and long tube evaporator –effect of boiling point elevation in evaporator calculation	6
2.2	Thermal design of evaporators: estimation of heat transfer area in multiple effect evaporators with negligible boiling point rise (double and triple effect forward feed) – effect of boiling point elevation in multiple effect evaporator calculation - trial and error method to estimate heat transfer	6

	area in each effect	
2.3	Process design of mechanical draft Cooling Towers: Estimation of air quantity, tower characteristics - number of diffusion units using graphical method	3
2.4	Process design of mechanical draft Cooling Towers: Estimation of water concentration, tower cross section area, fan hp, make-up water requirement	2

CHL411	PROCESS SIMULATION LAB	CATEGORY	L	T	P	CREDIT
		PCC	0	0	3	2

Preamble: This course helps the students to achieve skills and knowledge for simulation of a chemical plant using process simulators and interpret the outcome of the simulation.

Prerequisite: Basic understanding in process calculations, thermodynamics, chemical reaction engineering and process dynamics and control.

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

CO-1	To select an appropriate property package, operation or a group of operations to simulate a unit operation, a unit process or part of the process plant.
CO-2	To solve and analyse various forms of equations of state and plot the result using process simulators
CO-3	To solve and analyse various problems on vapour-liquid and reaction equilibria and plot the result using process simulators
CO-4	To simulate and analyse various types of unit operations and unit processes there by simulating an entire plant using process simulators.
CO-5	To perform dynamic simulation of an operation or a small portion of a process plant to predict the variation of operating parameters on a servo or regulator problem of process control.

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	PO1 2
CO-1	3	3	3	3	3				2		2	
CO-2	3	3	3	3	3				2		2	
CO-3	3	3	3	3	3				2		2	
CO-4	3	3	3	3	3				2		2	
CO-5	3	3	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.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. What are the factors to be considered in selecting the property package for a simulation?
2. How can a wrong selection of property package affect the outcome of simulation?
3. What are the operations to be combined to simulate an evaporator? Perform its simulation.

Course Outcome 2 (CO2)

1. Find the density of ambient air using a given equation of state. Study its variation as a function of temperature and pressure.
2. Find the molar volume of Methane at atmospheric conditions.
3. Compare the accuracy in predicting the molar volume using various equations of state given the experimental value.

Course Outcome 3 (CO3):

1. Derive the Rachford-Rice equation. Find the fraction vaporised and the vapour and liquid outlet compositions; given the feed characteristics.
2. Find the product composition in an equilibrium reaction at a given condition given the feed conditions
3. Study the effect of process conditions on the equilibrium conversion of a given reaction.

Course Outcome 4 (CO4):

1. Simulate a rigorous distillation column for the separation of the given components at a given condition.
2. Simulate a PFR for a given reaction and conditions
3. Simulate a CSTR for a given reaction and conditions

Course Outcome 5 (CO5):

1. Perform dynamic simulation of an operation of a process plant to predict the variation of operating parameters on a servo problem of process control.
2. Perform dynamic simulation of a small portion of a process plant to predict the variation of operating parameters on a regulator problem of process control.
3. Study the effect of controller parameters on the performance of control of a given operation.

LIST OF EXPERIMENTS (Minimum of 10 experiments are mandatory)

1. **Equations of state**: To study the effect of temperature and pressure on molar volume of a gas using various equations of state with the help of M.S.Excel/ Matlab/ DWSIM/Unisim etc.
2. **Phase equilibrium**: Derivation of Rachford-Rice equation. Solution of problems using Rachford-Rice equation with the help of M.S.Excel/ Matlab/ DWSIM/Unisim etc.
3. **Chemical Reaction equilibrium**: Study of various possibilities of finding the product composition in an equilibrium reaction using M.S.Excel/ Matlab/ DWSIM/Unisim etc.
4. **Mass Balances with Recycle Streams**: Study of material balance of chemical processes involving recycle of material streams using M.S.Excel/ Matlab/ DWSIM/Unisim etc.
5. **Simulation of Mass Transfer Equipment-1**: Steady-state simulation of shortcut distillation column using process simulators such as DWSIM/Unisim etc.
6. **Simulation of Mass Transfer Equipment-2**: Steady-state simulation of rigorous distillation column using process simulators such as DWSIM/Unisim etc.
7. **Simulation of Mass Transfer Equipment-3**: Steady-state simulation of absorption column using process simulators such as DWSIM/Unisim etc.
8. **Simulation of Kinetic Reactor-1**: Steady-state simulation of a Plug Flow Reactor using suitable example in process simulators such as DWSIM/Unisim etc.
9. **Simulation of Kinetic Reactor-2**: Steady-state simulation of a Mixed Flow Reactor using suitable example in process simulators such as DWSIM/Unisim etc.
10. **Simulation of process-1**: Steady-state simulation of a typical chemical plant involving heat exchangers/ coolers/ heaters using process simulators such as DWSIM/Unisim etc.
11. **Simulation of process-2**: Steady-state simulation of a typical chemical plant involving pumps/ compressors using process simulators such as DWSIM/Unisim etc.
12. **Simulation of process-3**: Steady-state simulation of a typical chemical plant involving a reactor and a mass transfer operation using process simulators such as DWSIM/Unisim etc.
13. **Dynamic simulation-1**: Dynamic simulation of a process part involving flow control.
14. **Dynamic simulation-2**: Dynamic simulation of a process part involving flow and level control.
15. **Dynamic simulation-3**: Dynamic simulation of a process part involving temperature control.

16. **Dynamic simulation-4**: Dynamic simulation of a process part involving temperature and pressure control.

Experiment- CO mapping

Expt No.	Topic	Cos
1	Equations of state	CO-1, CO-2
2	Phase equilibrium	CO-1, CO-3
3	Chemical Reaction equilibrium	CO-1, CO-3
4	Mass Balances with Recycle Streams	CO-1, CO-4
5	Simulation of Mass Transfer Equipment-1	CO-1, CO-4
6	Simulation of Mass Transfer Equipment-2	CO-1, CO-4
7	Simulation of Mass Transfer Equipment-2	CO-1, CO-4
8	Simulation of Kinetic Reactors-1	CO-1, CO-4
9	Simulation of Kinetic Reactors-2	CO-1, CO-4
10	Simulation of process-1	CO-1, CO-4
11	Simulation of process-2	CO-1, CO-4
12	Simulation of process-3	CO-1, CO-4
13	Dynamic simulation-1	CO-1, CO-5
14	Dynamic simulation-2	CO-1, CO-5
15	Dynamic simulation-3	CO-1, CO-5
16	Dynamic simulation-4	CO-1, CO-5

References:

1. Introduction to Chemical Engineering Computing by Bruce.A.Finlayson, Wiley Interscience.
2. Aspen Plus: Building and running a process model: Manual from Aspen Tech, US.
3. Hysys: An introduction to Chemical Engineering Simulation by Mohd. Kamaruddin Abd Hamid.
4. Dynamic modelling: Reference guides of process simulators such as DWSIM/Unisim etc.

CHQ413	SEMINAR	CATEGORY	L	T	P	CREDIT
		PWS	0	0	3	2

Preamble: The course 'Seminar' is intended to enable a B.Tech graduate to read, understand, present and prepare report about an academic document. The learner shall search in the literature including peer reviewed journals, conference, books, project reports etc., and identify an appropriate paper/thesis/report in her/his area of interest, in consultation with her/his seminar guide. This course can help the learner to experience how a presentation can be made about a selected academic document and also empower her/him to prepare a technical report.

Course Objectives:

- To do literature survey in a selected area ofstudy.
- To understand an academic document from the literate and to give a presentation about it.
- To prepare a technical report.

Course Outcomes [COs] : After successful completion of the course, the students will be able to:

CO1	Identify academic documents from the literature which are related to her/his areas of interest (Cognitive knowledge level: **Apply**).
CO2	Read and apprehend an academic document from the literature which is related to her/ his areas of interest (Cognitive knowledge level: **Analyze**).
CO3	Prepare a presentation about an academic document (Cognitive knowledge level: **Create**).
CO4	Give a presentation about an academic document (Cognitive knowledge level: **Apply**).
CO5	Prepare a technical report (Cognitive knowledge level: **Create**).

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1	1		2	1					3
CO2	3	3	2	3		2	1					3
CO3	3	2			3			1		2		3
CO4	3				2			1		3		3
CO5	3	3	3	3	2	2		2		3		3

Abstract POs defined by National Board of Accreditation			
PO#	**Broad PO**	**PO#**	**Broad PO**
PO1	Engineering Knowledge	PO7	Environment and Sustainability
PO2	Problem Analysis	PO8	Ethics
PO3	Design/Development of solutions	PO9	Individual and team work
PO4	Conduct investigations of complex problems	PO10	Communication
PO5	Modern tool usage	PO11	Project Management and Finance
PO6	The Engineer and Society	PO12	Life long learning

General Guidelines

- The Department shall form an Internal Evaluation Committee (IEC) for the seminar with academic coordinator for that program as the Chairperson/Chairman and seminar coordinator & seminar guide as members. During the seminar presentation of a student, all members of IEC shall be present.
- Formation of IEC and guide allotment shall be completed within a week after the University examination (or last working day) of the previous semester.
- Guide shall provide required input to their students regarding the selection of topic/ paper.
- Choosing a seminar topic: The topic for a UG seminar should be current and broad based rather than a very specific research work. It's advisable to choose a topic for the Seminar to be closely linked to the final year project area. Every member of the project team could choose or be assigned Seminar topics that covers various aspects linked to the Project area.
- A topic/paper relevant to the discipline shall be selected by the student during the semester break.
- Topic/Paper shall be finalized in the first week of the semester and shall be submitted to the IEC.
- The IEC shall approve the selected topic/paper by the second week of the semester.
- Accurate references from genuine peer reviewed published material to be given in the report and to be verified.

Evaluation pattern

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

Seminar Guide: 20 marks (Background Knowledge – 10 (The guide shall give deserving marks for a candidate based on the candidate's background knowledge about the topic selected), Relevance of the paper/topic selected – 10).

Seminar Coordinator: 20 marks (Seminar Diary – 10 (Each student shall maintain a seminar diary and the guide shall monitor the progress of the seminar work on a weekly basis and shall approve the entries in the seminar diary during the weekly meeting with the student), Attendance – 10).

Presentation: 40 marks to be awarded by the IEC (Clarity of presentation – 10, Interactions – 10 (to be based on the candidate's ability to answer questions during the interactive session of her/his presentation), Overall participation – 10 (to be given based on her/his involvement during interactive sessions of presentations by other students), Quality of the slides – 10).

Report: 20 marks to be awarded by the IEC (check for technical content, overall quality, templates followed, adequacy of references etc.).

CHD415	PROJECT PHASE I	CATEGORY	L	T	P	CREDIT
		PWS	0	0	6	2

Preamble: The course 'Project Work' is mainly intended to evoke the innovation and invention skills in a student. The course will provide an opportunity to synthesize and apply the knowledge and analytical skills learned, to be developed as a prototype or simulation. The project extends to 2 semesters and will be evaluated in the 7th and 8th semester separately, based on the achieved objectives. One third of the project credits shall be completed in 7th semester and two third in 8th semester. It is recommended that the projects may be finalized in the thrust areas of the respective engineering stream or as interdisciplinary projects. Importance should be given to address societal problems and developing indigenous technologies.

Course Objectives

- To apply engineering knowledge in practical problem solving.
- To foster innovation in design of products, processes or systems.
- To develop creative thinking in finding viable solutions to engineering problems.

Course Outcomes [COs] : After successful completion of the course, the students will be able to:

CO1	Model and solve real world problems by applying knowledge across domains (Cognitive knowledge level: **Apply**).
CO2	Develop products, processes or technologies for sustainable and socially relevant applications (Cognitive knowledge level: **Apply**).
CO3	Function effectively as an individual and as a leader in diverse teams and to comprehend and execute designated tasks (Cognitive knowledge level: **Apply**).
CO4	Plan and execute tasks utilizing available resources within timelines, following ethical and professional norms (Cognitive knowledge level: **Apply**).
CO5	Identify technology/research gaps and propose innovative/creative solutions (Cognitive knowledge level: **Analyze**).
CO6	Organize and communicate technical and scientific findings effectively in written and oral forms (Cognitive knowledge level: **Apply**).

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	1	2	2	2	1	1	1	1	2
CO2	2	2	2		1	3	3	1	1		1	1
CO3									3	2	2	1
CO4					2			3	2	2	3	2
CO5	2	3	3	1	2							1
CO6					2			2	2	3	1	1

Abstract POs defined by National Board of Accreditation			
PO#	**Broad PO**	**PO#**	**Broad PO**
PO1	Engineering Knowledge	PO7	Environment and Sustainability
PO2	Problem Analysis	PO8	Ethics
PO3	Design/Development of solutions	PO9	Individual and team work
PO4	Conduct investigations of complex problems	PO10	Communication
PO5	Modern tool usage	PO11	Project Management and Finance
PO6	The Engineer and Society	PO12	Lifelong learning

PROJECT PHASE I

Phase 1 Target

- Literature study/survey of published literature on the assigned topic
- Formulation of objectives
- Formulation of hypothesis/ design/ methodology
- Formulation of work plan and task allocation.
- Block level design documentation
- Seeking project funds from various agencies
- Preliminary Analysis/Modeling/Simulation/Experiment/Design/Feasibility study
- Preparation of Phase 1 report

Evaluation Guidelines & Rubrics

Total: 100 marks (Minimum required to pass: 50 marks).

- Project progress evaluation by guide: 30 Marks.
- Interim evaluation by the Evaluation Committee: 20 Marks.
- Final Evaluation by the Evaluation Committee: 30 Marks.
- Project Phase - I Report (By Evaluation Committee): 20 Marks.

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

Evaluation by the Guide

The guide/supervisor shall monitor the progress being carried out by the project groups on a regular basis. In case it is found that progress is unsatisfactory it shall be reported to the Department Evaluation Committee for necessary action. The presence of each student in the group and their involvement in all stages of execution of the project shall be ensured by the guide. Project evaluation by the guide: 30 Marks. This mark shall be awarded to the students in his/her group by considering the following aspects:

Topic Selection: innovativeness, social relevance etc. (2)

Problem definition: Identification of the social, environmental and ethical issues of the project problem. (2)

Purpose and need of the project: Detailed and extensive explanation of the purpose and need of the project. (3)

Project Objectives: All objectives of the proposed work are well defined; Steps to be followed to solve the defined problem are clearly specified. (2)

Project Scheduling & Distribution of Work among Team members: Detailed and extensive Scheduling with timelines provided for each phase of project. Work breakdown structure well defined. (3)

Literature survey: Outstanding investigation in all aspects. (4)

Student's Diary/ Daily Log: The main purpose of writing daily diary is to cultivate the habit of documenting and to encourage the students to search for details. It develops the students' thought process and reasoning abilities. The students should record in the daily/weekly activity diary the day to day account of the observations, impressions, information gathered and suggestions given, if any. It should contain the sketches & drawings related to the observations made by the students. The daily/weekly activity diary shall be signed after every day/week by the guide. (7)

Individual Contribution: The contribution of each student at various stages. (7)

EVALUATION RUBRICS for PROJECT Phase I: Interim Evaluation						
No.	**Parameters**	**Marks**	**Poor**	**Fair**	**Very Good**	**Outstanding**
1-a	Topic identification, selection, formulation of objectives and/or literature survey. (Group assessment) [CO1]	10	The team has failed to come with a relevant topic in time. Needed full assistance to find a topic from the guide. They do not respond to suggestions from the evaluation committee and/or the guide. No literature review was conducted. The team tried to gather easy information without verifying the authenticity. No objectives formed yet.	The team has identified a topic. The originally selected topic lacks substance and needs to be revised. There were suggestions given to improve the relevance and quality of the project topic. Only a few relevant references were consulted/ studied and there is no clear evidence to show the team's understanding on the same. Some objectives identified, but not clear enough.	Good evidence of the group thinking and brainstorming on what they are going to build. The results of the brainstorming are documented and the selection of topic is relevant. The review of related references was good, but there is scope of improvement. Objectives formed with good clarity, however some objectives are not realistic enough.	The group has brainstormed in an excellent manner on what they were going to build. The topic selected is highly relevant, real world problem and is potentially innovative. The group shows extreme interest in the topic and has conducted extensive literature survey in connection with the topic. The team has come up with clear objectives which are feasible.
			(0 – 3 Marks)	(4 – 6 Marks)	(7 - 9 Marks)	(10 Marks)
1-b	Project Planning, Scheduling and Resource/ Tasks Identification and allocation. (Group assessment) [CO4]	10	No evidence of planning or scheduling of the project. The students did not plan what they were going to build or plan on what materials / resources to use in the project. The students do not have any idea on the budget required. The team has not yet decided on who does what. No project journal kept.	Some evidence of a primary plan. There were some ideas on the materials /resources required, but not really thought out. The students have some idea on the finances required, but they have not formalized a budget plan. Schedules were not prepared. The project journal has no details. Some evidence on task allocation among the team members.	Good evidence of planning done. Materials were listed and thought out, but the plan wasn't quite complete. Schedules were prepared, but not detailed, and needs improvement. Project journal is presented but it is not complete in all respect / detailed. There is better task allocation and individual members understand about their tasks. There is room for improvement.	Excellent evidence of enterprising and extensive project planning. Gantt charts were used to depict detailed project scheduling. A project management/version control tool is used to track the project, which shows familiarity with modern tools. All materials / resources were identified and listed and anticipation of procuring time is done. Detailed budgeting is done. All tasks were identified and incorporated in the schedule. A well-kept project journal shows evidence for all the above, in addition to the interaction with the project guide. Each member knows well about their individual tasks.
			(0 – 3 Marks)	(4 – 6 Marks)	(7 - 9 Marks)	(10 Marks)
Phase 1 Interim Evaluation Total Marks: 20						

EVALUATION RUBRICS for PROJECT Phase I: Final Evaluation

Sl. No.	Parameters	Marks	Poor	Fair	Very Good	Outstanding
1-c	Formulation of Design and/or Methodology and Progress. (Group assessment) [CO1]	5	None of the team members show any evidence of knowledge about the design and the methodology adopted till now/ to be adopted in the later stages. The team has not progressed from the previous stage of evaluation.	The students have some knowledge on the design procedure to be adopted, and the methodologies. However, the team has not made much progress in the design, and yet to catch up with the project plan.	The students are comfortable with design methods adopted, and they have made some progress as per the plan. The methodologies are understood to a large extent.	Shows clear evidence of having a well- defined design methodology and adherence to it. Excellent knowledge in design procedure and its adaptation. Adherence to project plan is commendable.
			(0 – 1 Marks)	(2 – 3 Marks)	(4 Marks)	(5 Marks)
1-d	Individual and Teamwork Leadership (Individual assessment) [CO3]	10	The student does not show any interest in the project activities, and is a passive member.	The student show some interest and participates in some of the activities. However, the activities are mostly easy and superficial in nature.	The student shows very good interest in project, and takes up tasks and attempts to complete them. Shows excellent responsibility and team skills. Supports the other members well.	The student takes a leadership position and supports the other team members and leads the project. Shows clear evidence of leadership.
			(0 – 3 Marks)	(4 – 6 Marks)	(7 - 9 Marks)	(10 Marks)
1-e	Preliminary Analysis/ Modeling / Simulation/ Experiment / Design/ Feasibility study [CO1]	10	The team has not done any preliminary work with respect to the analysis/modeling/ simulation/experiment/design/feasibility study/ algorithm development.	The team has started doing some preliminary work with respect to the project. The students however are not prepared enough for the work and they need to improve a lot.	There is some evidence to show that the team has done good amount of preliminary investigation and design/ analysis/ modeling etc. They can improve further.	Strong evidence for excellent progress in the project. The team has completed the required preliminary work already and are poised to finish the phase I in an excellent manner. They have shown results to prove their progress.
			(0 – 3 Marks)	(4 – 6 Marks)	(7 - 9 Marks)	(10 Marks)

1-f	Documentation and presentation. (Individual & group assessment). [CO6]	5	The team did not document the work at all. The project journal/diary is not presented. The presentation was shallow in content and dull in appearance. The individual student has no idea on the presentation of his/her part.	Some documentation is done, but not extensive. Interaction with the guide is minimal. Presentation include some points of interest, but overall quality needs to be improved. Individual performance to be improved.	Most of the project details were documented well enough. There is scope for improvement. The presentation is satisfactory. Individual performance is good.	The project stages are extensively documented in the report. Professional documentation tools like LaTeX were used to document the progress of the project along with the project journal. The documentation structure is well-planned and can easily grow into the project report. The presentation is done professionally and with great clarity. The individual's performance is excellent.
			(0 – 1 Marks)	(2 – 3 Marks)	(4 Marks)	(5 Marks)
Total		**30**	**Phase - I Final Evaluation Marks: 30**			

EVALUATION RUBRICS for PROJECT Phase I: Report Evaluation						
Sl. No.	**Parameters**	**Marks**	**Poor**	**Fair**	**Very Good**	**Outstanding**
1-g	Report [CO6]	20	The prepared report is shallow and not as per standard format. It does not follow proper organization. Contains mostly Unacknowledged content. Lack of effort in preparation is evident.	Project report follows the standard format to some extent. However, its organization is not very good. Language needs to be improved. All references are not cited properly in the report.	Project report shows evidence of systematic documentation. Report is following the standard format and there are only a few issues. Organization of the report is good. Most of references are cited properly.	The report is exceptionally good. Neatly organized. All references cited properly. Diagrams/Figures, Tables and equations are properly numbered, and listed and clearly shown. Language is excellent and follows standard styles.
			(0 - 7 Marks)	(8 - 12 Marks)	(13 - 19 Marks)	(20 Marks)
Phase - I Project Report Marks: 20						

SEMESTER VII

PROGRAM ELECTIVE II

CHT413	FOOD PROCESSING AND TECHNOLOGY	CATEGORY	L	T	P	CREDIT
		PEC	2	1	0	3

Preamble: The familiarization of the food industry, the identification of the world and Indian food scenario, the different unit operations in food processing, the introduction of various food preservation techniques, the familiarization of various food sources and their processing techniques, application of various food processing and preservation techniques and the equipment and technology required and the familiarization of various food industries and food quality aspects.

Prerequisite: Nil

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

CO 1	Explain the importance of food quality, nutritive aspects, food additives and standards
CO 2	Discuss the food processing and packing methods
CO 3	Select suitable food preservation techniques
CO 4	Explain the production and utilization of food products from diary, meat, poultry and fish industries
CO 5	Describe treatment and disposal of food processing wastes

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

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	40	40	40
Understand	40	40	40
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):

1. Describe different emerging trends in food technology

Course Outcome 2 (CO2):

2. Explain briefly the wet cleaning methods in food raw materials.

Course Outcome 3(CO3):

3. Enumerate and explain different factors that influence the thermal destruction kinetics of the microorganisms in the heat treatment of food materials.

Course Outcome 4 (CO4):

4. With a neat flow sheet explain the steps involved in milk processing.

Course Outcome 5 (CO5):

5. Describe the safe disposal of wastes from a food industry.

Model Question paper

QP CODE: **PAGES: 3**

Reg No: ______________
Name: __________________________

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

Course Code: CHT413

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

FOOD PROCESSING AND TECHNOLOGY

PART – A

Answer All the Questions (10 x 3 = 30)

1. Define food additive. Enumerate any two intentional food additives that are used in food processing.
2. Define food technology. Enlist any four emerging trends in food technology.
3. Describe different sorting methods used in food industry.
4. Explain any two dry cleaning methods used in food industry.
5. How water activity and hydrostatic pressure affect the heat treatment in food preservation by microbial destruction.
6. Describe briefly the Flash 18 process used in food preservation.
7. Give an account for the technology of cardamom processing.
8. Distinguish between vegetable canning and vegetable dehydration.
9. Give an account of the importance of cheddar cheese.
10. How homogenization and aging are important in ice cream manufacture.

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

Module 1

11. a) Describe functional characteristics of chemical food additives? (9 marks)
    b) List out E numbers used in food additives. (5 marks)

OR

12. a) Enumerate the significant role of cholesterol in our body. (5 marks)
    b) Explain in detail different causes of food deterioration. (9 marks)

Module 2

13. a) Explain any four food conversion techniques used in food industries. Describe working of disc bowl centrifuge used in food industry. (9 marks)
    b) Describe different sorting methods used in food industry. (5 marks)

OR

14. a) Describe briefly the basic tools for food quality control. (9 marks)
    b) Explain use of Nanomaterials used for packing in food industry. (5 marks)

Module 3

15. a) With a neat diagram explain the working of steam blanchers and hot water blanchers used for food preservation. (9 marks)
    b) Explain briefly microwave heating. (5 marks)

OR

16. a) Discuss in detail the irradiation technique for food preservation. (9 marks)
    b) What is HTST pasteurisation in food preservation? (5 marks)

Module 4

17 a) Describe briefly the methods used for microbial decontamination of spices (9 marks)
   b) Explain the sand roasting process involved in the processing of pulses. (5 marks)

OR

18 a) Explain the production and processing of different rice products. (9 marks)

   b) Explain the harvesting and processing of black pepper. (5 marks)

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Module 5

19. a) Enumerate and describe different steps involved in meat preservation. (9marks)
    b) Give an account of the importance of cheddar cheese. (5 marks)

OR

20. a) Explain the role of Gasification and Mechanical biological treatment in food waste management. (9 marks)
    b) Explain the processing of any one non-carbonated non alcoholic beverages. (5 marks)

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Syllabus

Module 1: General aspects, food constituents, food additives and food deterioration (6 Hrs.)

General aspects of food industry World and Indian food needs Various food constituents and additives Food deteriorative factors and their control.

Module 2: Food processing (7 Hrs.)

Preliminary processing methods. Unit operations in Food Processing. Food conversion techniques and equipment used Food quality control and nutritive aspects

Module 3: Food preservation and packing techniques (7 Hrs.)

Hot and cold preservation techniques Irradiation and microwave heating Fermentation and Pickling, packing methods

Module 4: Cereals, pulses, vegetables, fats and oils (7 Hrs.)

Production and processing of cereals, pulses, Production and processing of vegetables, spices fats and oils

Module 5: Food Industries and safe disposal of wastes (8 Hrs.)

Food industries - Diary products, meat, poultry and fish products, Beverage Industry- Soft and Alcoholic. Treatment and disposal of food processing wastes

Text/Reference Books

1. B.Sivasankar, Food Processing and Preservation, PHI Learning Pvt. Ltd.
2. Badger, W.L, Banchero, J.T., Introduction to Chemical Engineering, McGraw Hill.
3. Food Industry Wastes: Disposal and Recovery; Herzka A & Booth RG; 1981, Applied Science Pub Ltd.
4. Hall C.W, Farall A.W & Rippen A.L, Encyclopedia of Food Engineering, Van Nostrand, Reinhold, New York.
5. Heid J.L & Joslyn M.A, Fundamentals of Food Processing Operations, AVI Pub.
6. Unit Operations of Chemical Engineering: McCabe, Smith & Harriot, TMH, 5th edition.
7. V. Sathe, A First Course in Food Analysis, New Age International Pvt. Ltd. 1999.
8. Waston E.L., Elements of Food Engineering, Van Nostrand, Reinhold, New York.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Module 1**	**6**
1.1	Introduction, general aspects	1
1.2	Classes of nutrients	1
1.3	Food additives; different classes of food additives	2
1.4	Food deterioration and control	2
2	**Module 2**	**7**
2.1	Preliminary processing methods.	1
2.2	Unit operations in Food Processing	2
2.3	Food conversion techniques	2
24	Equipment used in food conversion	1
2.5	Quality control in food products, Policy for preserving nutritive aspects of food products	1
3	**Module 3**	**7**
3.1	Introduction Thermal destruction kinetics of microorganisms	2
3.2	Sterilization, pasteurization and blanching	1
3.3	Evaporation and drying	1
3.4	Food irradiation and microwave heating	1
3.5	Fermentation and pickling	1
3.6	Food packing different methods	1

4	**Module 4**	**7**
4.1	Production and processing of rice and wheat, bread manufacture	2
4.2	Pulse processing: puffing processing, sand roast method, flaking	1
4.3	Fats and oils: Refining, hydrogenation, interesterification	2
4.4	Harvesting and processing of vegetables.	1
4.5	Harvesting and processing of spices, decontamination	1
5	**Module 5**	**8**
5.1	Explanation of milk processing,	1
5.2	Manufacture of different dairy products like butter, cheese and ice cream	2
5.3	Meat and meat products, different preservation techniques	1
5.4	Different preservation techniques for fish	1
5.5	Beverage Industry- Soft and Alcoholic, carbonated nonalcoholic, alcoholic and non-carbonated nonalcoholic beverages	2
5.6	Causes and prevention of food lost, Food processing wastes, treatment and disposal	1

CHT423	OIL AND NATURAL GAS ENGINEERING	CATEGORY	L	T	P	CREDIT
		PEC	2	1	0	3

Preamble: The field of natural gas engineering is very much important for petroleum engineers specializing in gas processing technology. The course outlines an optimal balance between natural gas production, natural gas processing and gas transportation. An extensive treatise on natural gas engineering, both upstream and gas refining processes with key equipment and facility design will be covered. This course will also highlight the current status of production of natural gas through unconventional sources/technics and the applications of natural gas.

Prerequisite: Nil

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

CO1	Identify different source rocks from which hydrocarbons are generated.
CO2	Gain knowledge of how and why fluid hydrocarbons migrate from a source rock to reservoir rock, entrapment and accumulation of hydrocarbons.
CO3	Identify sources of natural gas and its applications in variety of fields.
CO4	Explain various methods of natural gas processing for dehydration and sweetening.
CO5	Describe gas compression, gas gathering and transport installation.

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										

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): Identify different source rocks from which hydrocarbons are generated.

1. Differentiate between source rocks, reservoir rocks and cap rocks.
2. Explain how original oil and gas in place calculated. Differentiate between recoverable reserves and original oil and gas in place.

Course Outcome 2 (CO2): Gain knowledge of how and why fluid hydrocarbons migrate from a source rock to reservoir rock, entrapment and accumulation of hydrocarbons.

1. Enlist various factors affecting the gas-liquid separation and processing of natural gas.

Course Outcome 3 (CO3): Identify sources of natural gas and its applications in variety of fields.

1. Explain how original oil and gas in place calculated. Differentiate between recoverable reserves and original oil and gas in place.

Course Outcome 4 (CO4): Explain various methods of natural gas processing for dehydration and sweetening.

1. Explain the glycol dehydration process with a neat sketch.

Course Outcome 5 (CO5): Describe gas compression, gas gathering and transport installation.

1. Elaborate on gas compressor design on mollier charts.
2. Write short notes on natural gas storage and pipelines.
3. Explain the NGL train process with neat flow diagram.

Model Question Paper

QP CODE: **PAGES: 2**

Reg No: ______________

Name: ______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SEVENTH SEMESTER B. TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: CHT423

OIL AND NATURAL GAS ENGINEERING

Max. Marks: 100 Duration: 3 Hours

PART – A

Answer All the Questions (10 x 3 = 30)

1. State the two mechanisms of natural gas formation.
2. Differentiate between associated and non-associated gas.
3. Differentiate between source rocks, reservoir rocks and cap rocks.
4. List the effects of hydrate formation in subsea system and give any two methods for preventing hydrate formation.
5. List various problems in the production of natural gas.
6. Enlist various factors affecting the gas-liquid separation and processing of natural gas.
7. List the major steps involved in lean oil absorption process.
8. Explain the hot potassium carbonate process.
9. Classify the mode of transport of LNG.
10. List the important terminologies used for underground storage.

PART – B

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

Module 1

11. Explain how original oil and gas in place calculated. Differentiate between recoverable reserves and original oil and gas in place. (14 marks)

OR

12. Explain the following terms: (i) Heavy and extra heavy oil, (ii) Natural bitumen, (iii) Shale oil, (iv) Tar sand, and (v) tight reservoirs. (14 marks)

Module 1I

13. Explain in detail, different hydrate production methods. (14 marks)

OR

14. Draw a Schematic diagram of CBM reservoir to understand heterogeneity. Explain how it is different from Shale Gas. (14 marks)

Module III

15. Explain the principle and operation of Vertical and Horizontal gas liquid separator with neat sketch. (14 marks)

OR

16. Size a gas-oil separator both horizontally and vertically for the following conditions. (14 marks)

    Gas flowrate = 5 MMscfd, Operating pressure = 800 psig

    Condensate flowrate = 200 bbl/MMscf

Module IV

17. a) Explain in detail solvent absorption for natural gas. (7 marks)

    b) Give different properties of a suitable solvent. (7 marks)

OR

18. a) Explain the parts of a reciprocating compressor. (7 marks)

    b) Elaborate on gas compressor design on mollier charts. (7 marks)

Module V

19. a) Write short notes on natural gas storage and pipelines (7 marks)

    b) Explain the NGL train process with neat flow diagram. (7 marks)

OR

20. a) Describe the safety and environmental considerations of LNG facility. (9 marks)

    b) Write a note on regasification process. (5 marks)

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Syllabus

Module 1 **(8 Hrs.)**

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 **(7 Hrs.)**

Conventional natural gas: Associated gas, non-associated gas, Gas condensate.

Unconventional production of natural gas: Coal bed methane, Natural gas hydrate, shale gas and tight gas sands.

Coal bed methane - Introduction, present status, formation and properties of coal bed methane.

Natural Gas Hydrate - Concepts and Structures, Evaluation and Prediction, Production Techniques.

Shale Gas - Exploration, Production - Drilling and completion.

Module 3 **(6 Hrs.)**

Estimation and Production of Natural Gas: Estimation of gas reserves by volumetric method – Production of natural gas – Pressure decline method – Problems in the production of natural gas.

Separation and Processing: Gas and liquid separation – internal construction of separators, types of separators, factors affecting separation, separator design, stage separation, low temperature separation.

Module 4 **(7 Hrs.)**

Dehydration of Natural gas: Water content of natural gas streams, hydrate control in gas production, dehydration systems - Glycol dehydration and Solid desiccant dehydration.

Acid gas removal: Metal oxide process, Slurry process, Amine process, Carbonate washing process, Methanol based process and Sulphur recovery process.

Compression of Natural Gas: Types of Compressors, Selection of reciprocating and centrifugal compressors, Thermodynamics of Compressors, Compression calculations.

Module 5 **(7 Hrs.)**

Gas flow measurement: Fundamentals, Methods of measurements, Orifice meters equation, turbine meters, Selection, Recording charts, Uncertainties in flow.

Gas Gathering, Transportation and Storage: Gas Gathering System, Steady State and Unsteady State Flow in Pipelines, Transmission of Natural Gas, Specifications. Underground Storage and Conservation of Natural Gas.

Liquefied Natural Gas: Gas treating before liquefaction- Liquefaction cycles- Storage of LNG, Transportation- Regasification and cold utilization of LNG. Economics - Plant efficiency - Safety and environmental considerations.

Text/Reference Books

1. Elements of Petroleum Geology, Richard, C. Selley, Elsevier, 1997.
2. Fundamental of Natural Gas Processing, Arthur J. Kidnay, William R. Parrish, Taylor and Francis, 2006.
3. Beggs D. H., "Gas Production Operations", OGCI Publications, 1984.
4. Natural Gas: A Basic Handbook, James G. Speight, Gulf Publishing Company, 2007.
5. Gas Conditioning and Processing, John M. Campbell, Volume 2, 7th Edition, Campbell Petroleum Series, 1992.
6. Ikoku, Chi, "Natural Gas Production Engineering", John Wiley and Sons, 1984.
7. Kumar Sanjay, "Gas Production Engineering", Gulf Publishing Company, TX, USA, 1987.

Course Contents and Lecture Schedule:

No.	Topic	No. of Lectures
1	**Module 1**	**8**
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	**Module 2**	**7**
2.1	Conventional natural gas: Associated gas, non-associated gas, Gas condensate.	1
2.2	Coal bed methane - Introduction, present status, formation and properties of coal bed methane.	2
2.3	Natural Gas Hydrate - Concepts and Structures, Evaluation and Prediction, Production Techniques.	2
2.4	Shale Gas - Exploration, Production - Drilling and completion.	2
3	**Module 3**	**6**
3.1	Estimation and Production of Natural Gas: Estimation of gas reserves by volumetric method – Production of natural gas – Pressure decline method – Problems in the production of natural gas.	3
3.2	Separation and Processing: Gas and liquid separation – internal construction of separators, types of separators, factors affecting separation, separator design, stage separation, low temperature separation.	3
4	**Module 4**	**7**
4.1	Dehydration of Natural gas: Water content of natural gas streams, hydrate control in gas production, dehydration systems - Glycol dehydration and Solid desiccant dehydration.	2
4.2	Acid gas removal: Metal oxide process, Slurry process, Amine process, Carbonate washing process, Methanol based process and Sulphur recovery process.	3
4.3	Compression of Natural Gas: Types of Compressors, Selection of	2

	reciprocating and centrifugal compressors, Thermodynamics of Compressors, Compression calculations.	
5	**Module 5**	**7**
5.1	Gas flow measurement: Fundamentals, Methods of measurements, Orifice meters equation, turbine meters, Selection, Recording charts, Uncertainties in flow.	2
5.2	Gas Gathering, Transportation and Storage: Gas Gathering System, Steady State and Unsteady State Flow in Pipelines, Transmission of Natural Gas, Specifications. Underground Storage and Conservation of Natural Gas.	2
5.3	Liquefied Natural Gas: Gas treating before liquefaction- Liquefaction cycles- Storage of LNG, Transportation- Regasification and cold utilization of LNG. Economics - Plant efficiency - Safety and environmental considerations.	3

CHT433	PROCESS MODELLING AND SIMULATION	CATEGORY	L	T	P	CREDIT
		PEC	2	1	0	3

Preamble: In chemical engineering, modelling and simulation are important tools for engineers and scientists to have better understanding about the behaviour of chemical processes and plants. Modelling and simulation are very useful to design, scale up and optimize pieces of equipment and chemical plants, for process control, for troubleshooting, for operational fault detection, for training of operators and engineers, for costing and operational planning, etc. A very important characteristic of modelling and simulation is its advantageous cost–benefit ratio because with a virtual chemical plant, obtained from the modelling and simulation, it is possible to predict different scenarios of operations and to test many layouts at almost no cost and in a safe way.

Basic prerequisites for the model are chemical and physical properties of pure components and mixtures, reaction kinetics and basic conservation laws and empirical equations. Process simulation describes processes in flow diagrams where unit operations are positioned and connected by-product streams. It solves the mass and energy balance to find a stable operating point on specified parameters.

Prerequisite: Basic principles of chemical engineering, Calculus

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

CO 1	Identify the concept of modelling and simulation of chemical engineering systems
CO 2	Describe the important physical phenomena and develop model equations for the given system.
CO 3	Demonstrate the model developing ability for various reactors and separation systems.
CO 4	Demonstrate the model developing ability for distributed systems.
CO 5	Develop the skill to simulate chemical engineering systems and 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	3	3	2								
CO 2	3	3	3	2								
CO 3	3	3	3	2								
CO 4	3	3	3	2	2						3	
CO 5	3	3	3	2							3	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): Identify the concept of modelling and simulation of chemical engineering systems

1. Define Modelling and Simulation.
2. What are the classification of Modelling techniques?
3. Explain principles of formulation.

Course Outcome 2 (CO2): Describe the important physical phenomena and develop model equations for the given system.

1. What are the Transport equations and equations of continuity?
2. What are the equations of state and chemical kinetics?
3. What are the equations of motion and energy equation.

Course Outcome 3 (CO3): Demonstrate the model developing ability for various reactors and separation systems

1. Develop the model of enclosed vessel boiling.
2. Develop the model of mixing vessel with reversible reaction.
3. Develop the model of batch distillation.

Course Outcome 4 (CO4): Develop models for chemical engineering systems.

1. Develop the model of jacketed tubular reactor.
2. Develop the model of ideal binary distillation column.
3. Develop the counter current liquid liquid heat exchanger.

Course Outcome 5 (CO5): Develop the skill to simulate chemical engineering systems and processes

1. Develop an algorithm for the simulation of gravity flow tank.
2. Develop an algorithm for the simulation of non isothermal CSTR.
3. Develop an algorithm for the simulation of binary distillation column.

Model Question paper

QP CODE: **PAGES: 2**

Reg No: ______________

Name: __________________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SEVENTH SEMESTER B. TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: CHT433

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

PROCESS MODELING AND SIMULATION

PART – A

Answer All the Questions (10 x 3 = 30)

1. Analyse between Deterministic and stochastic modelling.
2. Define modelling with an example.
3. Explain equation of state.
4. Explain law of mass action.
5. Develop the model of continuous flow tank
6. Develop the model of open vessel boiling.
7. Explain distributed systems with an example.
8. Explain the general modelling scheme of reaction kinetics.
9. Explain simulation with an example
10. Write the model equations for the simulation of two CSTRs in series.

PART – B

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

Module 1

11. Explain the classification of modeling techniques. (14 marks)

OR

12. Explain the principles of formulation. . (14 marks)

Module 2

13. Explain the Transport equations, Energy equation, Continuity equation and equation of motion. . (14 marks)

OR

14. A stream of water flowing horizontally with a speed of 15 m/s pushes out of a tube of cross-sectional area 1 m^2 and hits at a vertical wall nearby. What is the force exerted on the wall by the impact of water, assuming that it does not rebound? Density of water = 1000Kg/m^3. . (14 marks)

Module 3

15. Develop the model for a continuous flow tank with level Z, inflow F1 outflow F2 and concentration C1 which is connected to a CSTR where a first order reaction takes place with exit concentration C2 , outflow F3 and volume V. . (14 marks)

OR

16. Develop the model for batch distillation. . (14 marks)

Module 4

17. Develop the model for counter current heat exchanger. . (14 marks)

OR

18. Develop the model for jacketed tubular reactor with a unimolecular reaction taking place on the surface of catalyst bed. . (14 marks)

Module 5

19. Develop an algorithm for the simulation of Non isothermal CSTR. (14 marks)

OR

20. Develop an algorithm for the simulation of binary distillation column. (14 marks)

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Syllabus

Module 1: Definitions and basic concepts **(7 Hrs.)**

Definition of Modeling, Simulation, Classification of modeling and simulation, Types of modelling equations-Basic concepts, Basic modeling principles, Importance of modeling and simulation, Advantages and limitations of modeling and simulation, Review of simulation software.

Module 2: Fundamental laws of chemical engineering **(7 Hrs.)**

Energy equations, continuity equation, equation of motion, transport equations, equations of state, Equilibrium states and chemical kinetics.

Module 3: Mathematical models for lumped systems **(7 Hrs.)**

Mathematical models- Continuous flow tanks, Mixing vessel without reaction, Isothermal reactor with irreversible and reversible reaction. Non-isothermal steam jacketed reactor, Dynamics of solid particle falling in liquid, Boiling-open and enclosed vessel, Batch distillation, Ideal binary distillation column.

Module 4: Mathematical models for Distributed systems **(7 Hrs.)**

Mathematical models- Jacketed tubular reactor, Counter current liquid-liquid double-pipe heat exchanger.

Module 5: Simulation of dynamic systems **(7 Hrs.)**

Continuous flow tank, Isothermal CSTR in series, Non-isothermal CSTR, Binary distillation column.

Text Books

1. Franks R.G.E., Mathematical Modeling in Chemical Engineering, John Wiley
2. Luyben W.L., Process Modeling, Simulation and Control for Chemical Engineers, McGraw Hill Inmternational Edition
3. Amiya K.Jana, Computer Process Modelling and Computer Simulation, Prentice Hall of India.

Reference Books

1. Biquette W.B., Process Dynamics - Modeling Analysis and Simulation, Prentice Hall of India
2. John Ingham et.al., Chemical Engineering Dynamics - Modeling with PC Simulation,VCH Publishers

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Module 1**	**7**
1.1	Definitions of Modelling and Simulation.	2
1.2	Importance and use of modelling and simulation.	1
1.3	Types of modelling equations-Basic concepts	1
1.4	Principles of formulation.	1
1.5	Classification of Modeling techniques.	1
1.6	Advantages and limitations of modelling and simulation, Review of simulation software.	1
2	**Module 2**	**7**
2.1	Fundamental laws, Continuity and energy equation.	2
2.2	Fundamental laws-Energy equation continued.	2
2.3	Fundamental laws Equation of Motion and Transport equation.	2
2.4	Fundamental laws-Equilibrium, kinetics, equation of states.	1
3	**Module 3**	**7**
3.1	Continuous flow tank. Mixing vessel	1
3.2	Isothermal reactor with irreversible and reversible reaction	1
3.3	Non-isothermal steam jacketed reactor	1
3.4	Dynamics of solid particle falling in liquid.	1
3.5	Boiling in open and enclosed vessel, Batch distillation	2
3.6	Ideal binary distillation column.	1
4	**Module 4**	7
4.1	Distributed system- basic concepts	2
4.2	Jacketed tubular reactor	3
4.3	Counter current liquid-liquid double-pipe heat exchanger.	2
5	**Module 5**	**7**
5.1	Continuous flow tank	2
5.2	Isothermal CSTR in series	1
5.3	Non-isothermal CSTR	2
5.4	Binary distillation column.	2

****

CHT443	CORROSION ENGINEERING	CATEGORY	L	T	P	CREDIT
		PEC	2	1	0	3

Preamble: Corrosion engineering is an engineering specialty that applies scientific, technical, engineering skills, and knowledge of natural laws and physical resources to design and implement materials, structures, devices, systems, and procedures to manage corrosion.
This course is intended to impart knowledge on the importance of corrosion and its prevention and control in process industries.

Prerequisite: Nil

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

CO 1	Summarize the principles of corrosion considering electrochemical, environmental, metallurgical and other aspects.
CO 2	Identify and explain the different types of corrosion.
CO 3	Explain various corrosion testing techniques.
CO 4	Explain various corrosion control techniques.
CO 5	Select the appropriate corrosion control technique for different engineering materials and industries.
CO6	Identify corrosion-related problems and propose viable solutions.

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				2	2					
CO 3	3					1	1					
CO 4	3	3				1	1					
CO 5	3	3				2	3	2				
CO6	3	3				3	3	2				

Assessment Pattern

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

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

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

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

Course Level Assessment Questions

Course Outcome 1 (CO1): Summarize the principles of corrosion considering electrochemical, environmental, metallurgical and other aspects.

1. Explain the electrochemical aspects of corrosion.
2. Explain the environmental aspects of corrosion.

Course Outcome 2 (CO2): Identify and explain the different types of corrosion

1. Explain galvanic corrosion with a neat sketch.
2. Explain pitting corrosion with a neat sketch.

Course Outcome 3 (CO3): Explain various corrosion testing techniques.

1. Explain galvanostatic method of corrosion testing.
2. Explain linear polarisation method of corrosion testing.

Course Outcome 4 (CO4): Explain various corrosion control techniques.

1. Explain flame spraying method of applying coatings.
2. What are inhibitors, different types of inhibitors, and limitations of inhibitors?

Course Outcome 5 (CO5): Select the appropriate corrosion control technique for different engineering materials and industries.

1. Describe the corrosion control measures employed in composites and polymers.
2. Describe the corrosion control techniques employed in marine industry.

Course Outcome 6 (CO6): Analyse corrosion-related problems and propose viable solutions.

1. What is the need for conducting corrosion auditing in industries.
2. Explain the corrosion related problems in fertilizer industry.

Model Question paper

QP CODE: **PAGES: 3**

Reg No: ______________
Name: __________________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
SEVENTH SEMESTER B. TECH DEGREE EXAMINATION, MONTH & YEAR
Course Code: CHT443

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

CORROSION ENGINEERING

PART – A

Answer All the Questions (10 x 3 = 30)

1. A steel rod having a surface area of 31.89 cm2 is dipped in an electrolyte solution. 0.017 g of steel was lost after an exposure time of 7 hours. Density of steel is 8.05 g/cm^3 . Determine the corrosion rate of the sample in 'mpy'.
2. Explain the effect of temperature on corrosion.
3. List and explain about three beneficial applications of galvanic corrosion.
4. Explain knife-line attack.
5. Explain how coatings helps in preventing corrosion.
6. Explain linear polarization method of corrosion testing.
7. Explain the principle of thermogravimetric technique for corrosion testing and monitoring.
8. What are inhibitors?
9. Mention any three corrosion related problems in marine industry.
10. Suggest any three suitable solutions for controlling corrosion in ceramics.

PART – B

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

Module 1

11. (a) Differentiate activation polarization and concentration polarization with suitable diagrams. (7marks)
    (b) Discuss the direct and indirect economic costs of corrosion. (7 marks)

OR

12. (a) Define corrosion. Mention the deleterious effects of corrosion. (7marks)
    (b) Explain the effect of metallurgical aspects on corrosion. (7marks)

Module 2

13. (a) Explain the mechanism of crevice corrosion with appropriate diagrams. (7marks)
    (b) What is stress corrosion cracking and discuss about the effect of environmental factors on stress corrosion. (7marks)

OR

14. Explain galvanic corrosion and pitting corrosion with neat sketches. (14marks)

Module 3

15. Explain the procedure of salt spray test for corrosion testing with the help of a neat sketch. (14marks)

OR

16. Explain impedance spectroscopy with a neat sketch. (14marks)

Module 4

17. Explain how cathodic protection and anodic protection helps in preventing corrosion. (14marks)

OR

18. Explain the various techniques used for corrosion prevention of a material. (14marks)

Module 5

19. (a) Explain the corrosion map of India. (7marks)
    (b) Explain the various methods used for preventing corrosion in concrete structures. (7marks)

OR

20. (a)Explain the various techniques used for preventing corrosion in fertilizer industries. (8marks)
21. (b) How is corrosion auditing carried out in industries? (6marks)

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Syllabus

Module 1: Definition and importance of corrosion (7 Hrs.)

Definition and importance of corrosion: Principles of corrosion phenomenon: Corrosion rate expressions, Electrochemical aspects, Environmental effects, Metallurgical and other aspects.

Module 2: Different forms of corrosion (7 Hrs.)

Different forms of corrosion: Galvanic or two metal corrosion, Crevice corrosion, Pitting, Intergranular corrosion, Selective leaching, Erosion corrosion, Stress corrosion, Hydrogen damage.

Module 3 Corrosion testing and monitoring (6 Hrs.)

Corrosion testing and monitoring: Non-electrochemical and electrochemical methods: potentiostat, Tafel extrapolation, linear polarization, galvanostat, impedance spectroscopy, thermogravimetric technique, salt spray test, weight change measurements.

Module 4: Corrosion prevention (7 Hrs.)

Corrosion prevention: Design and coatings, inhibitors and surface engineering, cathodic protection and anodic protection.

Module 5 Corrosion and its control in different engineering materials and industries (8 Hrs.)

Corrosion and its control in different engineering materials: concrete structures, duplex, super duplex stainless steels, ceramics, composites and polymers.

Corrosion and its control in industries: Power, Process, Petrochemical, ship building, marine and fertilizer industries. Corrosion auditing in industries, Corrosion map of India.

Text Books

1. Fontana M. G., Corrosion Engineering, Tata McGraw Hill, 3rd Edition, 2005.
2. Jones D. A, Principles and Prevention of Corrosion, Prentice-Hall, Inc., 2nd Edition, 1996.

Reference Books

1. Scully J. C, The Fundamentals of Corrosion, 2nd Ed., Pergamon Press.
2. Stansbury E. E. and Buchanan, R. A, Fundamentals of Electrochemical Corrosion, , ASM International.
3. Uhlig H. H. and Revie R. W, Corrosion and Corrosion Control, 3rd Ed., John Wiley & Sons.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Module 1**	**7**
1.1	Definition and importance of corrosion	1
1.2	Principles of corrosion phenomenon	1
1.3	Corrosion rate expressions	1
1.4	Electrochemical aspects	1
1.5	Environmental effects	2
1.6	Metallurgical and other aspects	1
2	**Module 2**	**7**
2.1	Galvanic or two metal corrosion	1
2.2	Crevice corrosion	1
2.3	Pitting	1
24	Intergranular corrosion	1
2.5	Selective leaching	1
2.6	Erosion corrosion	1
2.7	Stress corrosion, Hydrogen damage	1
3	**Module 3**	**6**
3.1	Introduction to Non-electrochemical and electrochemical methods	1
3.2	Potentiostat	1
3.3	Tafel extrapolation, linear polarization	1
3.4	Galvanostat, impedance spectroscopy	1
3.5	Thermogravimetric technique	1
3.6	Salt spray test, weight change measurements.	1
4	**Module 4**	**7**
4.1	Design and coatings	1
4.2	Inhibitors and surface engineering	2
4.3	Cathodic protection	2
4.4	Anodic protection	2
5	**Module 5**	**8**
5.1	Corrosion and its control in concrete structures	1
5.2	Corrosion and its control in duplex, super duplex stainless steels	1
5.3	Corrosion and its control in ceramics	1
5.4	Corrosion and its control in composites and polymers	1
5.5	Corrosion and its control in Power, Process, Petrochemical industries	1
5.6	Corrosion and its control in ship building industries.	1
5.7	Corrosion and its control in marine and fertilizer industries	1
5.8	Corrosion auditing in industries, Corrosion map of India	1

CHT453	PROJECT ENGINEERING	CATEGORY	L	T	P	CREDIT
		PEC	2	1	0	3

Preamble: The objective is set out to impart the undergraduate students, a basic knowledge in project planning, plant process design, economic evaluation and financial control. Emphasis is given to process plants due to the fact that these are usually more complicated than other types of industrial plants, yet both in fact follow very similar steps along project implementation practices.

Prerequisite: Nil

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

CO1	Identify process equipment and P&ID symbols and read the process flow diagrams of a chemical plant.
CO2	Describe the role of a project engineer in the design and erection of a process plant.
CO3	Develop skills required for project planning & formulation and analyze processes for project execution & control.
CO4	Describe the fundamental elements of a contract and choose the right contract type for a given situation.
CO5	Differentiate the equipment and able to prepare a specification sheet.
CO6	Estimate the capital investment required for an industrial process and determine the total product cost associated with an industrial process.

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			
CO 2	3	2										
CO 3	3	2										
CO 4	3	2						2				
CO 5	3	2						2	2			
CO 6	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
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): Identify process equipment and P&ID symbols and read the process flow diagrams of a chemical plant.

1. List the types of flow diagrams that are in common use.
2. List and explain different stages in the production of customer-built chemical processing equipment.

Course Outcome 2 (CO2): Describe the role of a project engineer in the design and erection of a process plant.

1. State and explain various factors for techno-economic feasibility survey of a chemical process plant.
2. Explain the principles of the storage layout and equipment layout in a process plant.

Course Outcome 3 (CO3): Develop skills required for project planning & formulation and analyze processes for project execution & control.

1. Write a note on PERT and CPM mentioning their role in scheduling of projects.
2. Explain the significance of guarantee run.

Course Outcome 4 (CO4): Describe the fundamental elements of a contract and choose the right contract type for a given situation.

1. Explain the procedure of tendering and selection of successful contractor for projects.

2. As a project manager you are vested with the responsibility of bidding for an industrial project. What bidding strategies would you consider? Discuss with justification.

Course Outcome 5 (CO5): Differentiate the equipments and able to prepare specification sheet.

1. State the advantages of standard equipment over special equipment.
2. State the preliminary specifications for equipments.
3. Prepare the specification sheet for a heat exchanger.

Course Outcome 6 (CO6): Estimate the capital investment required for an industrial process and determine the total product cost associated with an industrial process.

1. List the items that are included in the fixed capital investment, for chemical process industry.
2. Explain the method of determining profitability using net present value method.
3. List and explain different methods for estimating capital investment.

Model Question Paper

QP CODE: **PAGES: 3**

Reg No: ______________ **Name: ______________**

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SEVENTH SEMESTER B. TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: CHT453

Max. Marks: 100 Duration: 3 Hours

PROJECT ENGINEERING

PART – A

Answer All the Questions (10 x 3 = 30)

1. Differentiate between a commercial and a semicommercial plant.
2. List the types of flow diagrams that are in common use.
3. Explain how plant terrain influences the site selection?
4. Briefly discuss on the venting and draining in process plant design
5. Explain the different stages in site development.
6. Write a note on cost-plus contract.
7. Differentiate between scope estimate and contractor's estimate.
8. List the items that are included in the fixed capital investment, for chemical process industry.
9. Explain the method of determining profitability using net present value method.
10. Write a note on the two major financial reporting documents.

PART – B

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

Module 1

11. List and explain the main factors to be considered in the feasibility study of a project.

OR

12. A plant layout is to be prepared for a batch process which involves process equipments such as plug flow reactor, an overhead condenser, steam heating jacket for reactor, a centrifuge and two centrifugal pumps. Discuss the factors to be considered in preparing this layout.

Module 1I

13. Explain the following terms in network analysis: (i) Event, (ii) Critical Path, (iii) Dummy Activity and (iv) Float.

OR

14. Define a pilot plant. Write the subsequent development stages of semi-commercial / commercial production.

Module III

15. List and explain the major steps in company formation.

OR

16. Explain the procedure of tendering and selection of successful contractor for projects

Module IV

17. Write a note on institutions in India, supporting the industry for long term financing.

OR

18. State the preliminary specifications for equipments. Prepare the specification sheet for a heat exchanger.

Module V

19. Explain the need of working capital for an industrial plant and write the components of money to be provided.

OR

20. Write short notes on (i) Fixed Costs and Cost of Production, (ii) Break-even Analysis.

****

Syllabus

Module 1 **(8 Hours)**

Classification of Projects, Scope of Project engineering - the role of project engineer.
Development of project – R&D, TEFR, Importance of Laboratory development – Bench scale experiments – pilot plant studies – Semi-commercial plant.
Plant location and site selection – preliminary data for construction projects - process engineering - flow diagrams – plot plans - engineering design and drafting.

Module 2 **(7 Hours)**

Planning and scheduling of projects – use of bar chart, PERT/ CPM - Critical path calculations.
Site development – foundation – Erection and site fabrication – Construction – Alignment and insulation – Start up and commissioning – Trial runs – Guarantees sums and hand over.

Module 3 **(6 Hours)**

Company formation process license – Technology Transfer – statutory sanctions.
Contracts and Contractors – Introduction, detailing of scope of work, factors in selecting scope of work, detailing of contract types, Factors in selecting type of contract, contractor selection.

Module 4 **(6 Hours)**

Selection of process equipments: Standard versus special equipment selection criteria, specification sheets.
Project financing: Means of finance, financial institutions, special schemes, Financing with special reference to financial institutions in India, key financial indicators and ratios, personnel recruitment and training.

Module 5 **(8 Hours)**

Scope of piping engineering, pipe sizing technique, Codes and standards, Piping design, thermal insulation and buildings, safety in plant design.
Economic evaluation of projects - Capital requirements and cost of production – profitability -Break even analysis and minimum cost analysis.

Text Books:

1. Rase & Barrow, Project Engineering of Process Plants, John Wiley

Reference Books:

1. Bhasin, S.D.: “Project Engineering of Process Plants”, Chemical Engineering Education Development Centre, I.I.T., Madras (1979).
2. Peter S. Max & Timmer Haus, “Plant design and economics for chemical engineers”. Mc Graw Hill (2002).
3. Srinath L. S., “PERT and CPM.” affiliated east press Pvt. Ltd., New York (1973)
4. Perry J. H. “Chemical engineering handbook” 7^{TH} ed. Mc Graw Hill (1997).
5. Jelen. F. C., “Cost and optimization in engineering”. Mc Graw Hill (1983).
6. Frederick B. Plummer, “Project Engineering”, BH
7. Ernest E. Ludwig, “Applied project engineering and Management”, Gulf Pub. Co., (1988)

Course Contents and Lecture Schedule:

No.	Topic	No. of Lectures
1	**Module 1**	**8**
1.1	Classification of Projects, Scope of Project engineering - the role of project engineer.	1
1.2	Development of project – R&D, TEFR	2
1.3	Importance of Laboratory development – Bench scale experiments – pilot plant studies – Semi-commercial plant.	1
1.4	Plant location and site selection – preliminary data for construction projects - process engineering	2
1.5	flow diagrams – plot plans - engineering design and drafting	2
2	**Module 2**	**7**
2.1	Planning and scheduling of projects – use of bar chart	1
2.2	PERT/ CPM - Critical path calculations.	2
2.3	Site development – foundation – Erection and site fabrication – Construction – Alignment and insulation – Startup and commissioning – Trial runs – Guarantees sums and hand over.	4
3	**Module 3**	**6**
3.1	Company formation process license – Technology Transfer – statutory sanctions.	2
3.2	Contracts and Contractors – Introduction, detailing of scope of work, factors in selecting scope of work.	2
3.3	Detailing of contract types, Factors in selecting type of contract, contractor selection.	2
4	**Module 4**	**6**
4.1	Selection of process equipment: Standard versus special equipment selection criteria, specification sheets.	2
4.2	Project financing: Means of finance, financial institutions, special schemes, Financing with special reference to financial institutions in India,	1
4.3	Key financial indicators and ratios.	2
4.4	Personnel recruitment and training.	1
5	**Module 5**	**8**
5.1	Scope of piping engineering, pipe sizing technique, Codes and standards.	1
5.2	Piping design, thermal insulation and buildings, safety in plant design.	2
5.3	Economic evaluation of projects - Capital requirements and cost of production- Profitability.	2
5.4	Break even analysis and minimum cost analysis.	3

CHT463	INTRODUCTION TO DATA ANALYSIS	CATEGORY	L	T	P	CREDIT
		PEC	2	1	0	3

Preamble: Students, researchers, and engineers want to analyze the experimental data in a scientific and rigorous manner and communicate the outcomes in reports, theses, or publications in an unambiguous manner. From a basic knowledge in calculus, linear algebra and probability and statistics the course enables the participants to acquire knowledge and skills in statistical data analysis and design of experiments. The course will introduce essential tools for data analysis by discussions on popular probability distributions, the concept of random samples, linear regression, and hypothesis testing. In the topic of design of experiments the course is planned to provide an overview of factorial design, orthogonal designs, higher order designs and guidelines for selecting the most appropriate design for an experiment.

Prerequisite: A basic knowledge in calculus, linear algebra and probability and statistics

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

CO 1	Develop and interpret the graphical representation of data.
CO 2	Analyse the data using descriptive statistics.
CO 3	Distinguish the properties and applications of important statistical distributions.
CO 4	Analyse the data using inferential statistics.
CO 5	Develop and interpret the linear regression analysis.
CO 6	Compare different experimental design strategies.

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	2						
CO 2	3	3	3	3	3	2						
CO 3	3	3	3	3	3							
CO 4	3	3	3	3	3						2	
CO 5	3	3	3	3	3						2	
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	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 anyone. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1): To develop and interpret the graphical representation of data

1. Develop the Stem-and-Leaf Plot for the following data of durations (in minutes) for completion of the reaction

42	45	49	50	51	51	51	51	53	53
55	55	56	56	57	58	60	66	67	67
68	69	70	71	72	73	73	74	75	75
75	75	76	76	76	76	76	79	79	80
80	80	80	81	82	82	82	83	83	84
84	84	85	86	86	86	88	90	91	93

2. Following are measurements of soil concentrations (in mg/kg) of chromium (Cr) and nickel (Ni) at 20 sites in an industrial area.

Cr:	34	1	511	2	574	496	322	424
	269	140	244	252	76	108	24	38
	18	34	30	191				
Ni:	23	22	55	39	283	34	159	37

	61	34	163	140	32	23	54	837
	64	354	376	471				

a. Construct a histogram for each set of concentrations.
b. Construct comparative boxplots for the two sets of concentrations.
c. Using the boxplots, what differences can be seen between the two sets of concentrations?

Course Outcome 2 (CO2): To analyse the data using descriptive statistics

1. Find the first and third quartiles of the sample values of fracture stress (in megapascals) measured for a sample of 24 mixtures of hot-mixed asphalt (HMA). Data: 30, 75, 79, 80, 80, 105, 126, 138, 149, 179, 179, 191, 223, 232, 232, 236, 240, 242, 245, 247, 254, 274, 384, 470
2. Find the sample variance and the sample standard deviation of the temperature data: 165.51 oC, 172.30 ^oC, 168.31 ^oC, 167.05 ^oC, 176.23 ^oC and 170.68 ^oC

Course Outcome 3 (CO3): To distinguish the properties and applications of important statistical distributions

1. Give the Properties of log-normal distribution
2. Give and explain the Central Limit Theorem

Course Outcome 4 (CO4): To analyse the data using inferential statistics

1. Give the Steps in Performing a Hypothesis Test
2. What are the possible errors in hypothesis Tests?

Course Outcome 5 (CO5): To develop and interpret the linear regression analysis

1. Define and explain Correlation Coefficient
2. A chemical engineer is studying the effect of temperature and stirring rate on the yield of a certain product. The process is run 16 times, at the settings indicated in the following table. The units for yield are percent of a theoretical maximum.

Temperature(◦C)	Stirring Rate (rpm)	Yield (%)
110	30	70.27
110	32	72.29
111	34	72.57
111	36	74.69
112	38	76.09
112	40	73.14
114	42	75.61
114	44	69.56
117	46	74.41
117	48	73.49
122	50	79.18
122	52	75.44
130	54	81.71
130	56	83.03
143	58	76.98
143	60	80.99

a. Compute the correlation between temperature and yield, between stirring rate and yield, and between temperature and stirring rate.
b. Do these data provide good evidence that increasing the temperature causes the yield to increase, within the range of the data? Or might the result be due to confounding? Explain.
c. Do these data provide good evidence that increasing the stirring rate causes the yield to increase, within the range of the data? Or might the result be due to confounding? Explain.

Course Outcome 6 (CO6): To compare different experimental design strategies

1. Differentiate between central composite design and Box Behnken design of response surface methodology.
2. List the assumptions of for Two-Way ANOVA

Model Question paper

QP CODE: **PAGES: 3**

Reg No: ______________

Name: ___________________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SEVENTH SEMESTER B. TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: CHT463

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

INTRODUCTION TO DATA ANALYSIS

PART – A

Answer All the Questions (10 x 3 = 30)

1. Develop the Dot Plot for the following data of durations (in minutes) for completion of the reaction

42	45	49	50	51	51	51	51	53	53
55	55	56	56	57	58	60	66	67	67
68	69	70	71	72	73	73	74	75	75
75	75	76	76	76	76	76	79	79	80
80	80	80	81	82	82	82	83	83	84
84	84	85	86	86	86	88	90	91	93

2. Find the 65th percentile of the sample values of fracture stress (in megapascals) measured for a sample of 24 mixtures of hot-mixed asphalt (HMA). Data: 30, 75, 79, 80, 80, 105, 126, 138, 149, 179, 179, 191, 223, 232, 232, 236, 240, 242, 245, 247, 254, 274, 384, 470
3. Define normal distribution
4. Aluminium sheets used to make beverage cans have thicknesses (in thousandths of an inch) that are normally distributed with mean 10 and standard deviation 1.3. A particular sheet is 10.8 thousandths of an inch thick. Find the *z*-score.
5. Explain idea of computing the power of a hypothesis test
6. List two conditions/ assumptions under which the standard one-way ANOVA hypothesis tests are valid
7. Comment on the Matrix approach to linear regression
8. Explain the benefits of planned experimentation
9. Explain the properties of orthogonal designs
10. Explain the importance of Centre Points in Central Composite Designs

PART – B

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

Module 1

11. (a) What is information available in a box-and- whisker plot? (4marks)

(b) A sample of 100 adult women was taken, and each was asked how many children she had. The results were as follows:

Children	0	1	2	3	4	5
Number of women	27	22	30	12	7	2

i. Find the sample mean number of children.

ii. Find the sample standard deviation of the number of children.

iii. Find the sample median of the number of children.

iv. What is the first quartile of the number of children?

v. What proportion of the women had more than the mean number of children? (10marks)

OR

12. (a) Forty-five specimens of a certain type of powder were analysed for sulphur trioxide content. Following are the results, in percent. The list has been sorted into numerical order.

14.1	14.4	14.7	14.8	15.3	15.6	16.1	16.6	17.3
14.2	14.4	14.7	14.9	15.3	15.7	16.2	17.2	17.3
14.3	14.4	14.8	15	15.4	15.7	16.4	17.2	17.8
14.3	14.4	14.8	15	15.4	15.9	16.4	17.2	21.9
14.3	14.6	14.8	15.2	15.5	15.9	16.5	17.2	22.4

i. Construct a stem-and-leaf plot for these data.

ii. Construct a histogram for these data.

iii. Construct a dot-plot for these data.

iv. Construct a boxplot for these data. Does the boxplot show any outliers? (10marks)

(b) The following values of fracture stress (in megapascals) were measured for a sample of 24 mixtures of hot-mixed asphalt (HMA). Data: 30, 75, 79, 80, 80, 105, 126, 138, 149, 179, 179, 191, 223, 232, 232, 236, 240, 242, 245, 247, 254, 274, 384, 470

Compute the mean, median, and the 20% trimmed mean. (4marks)

Module 2

13 (a) The following table presents probabilities for the number of times that a certain computer system will crash in a week. Let *A* be the event that there are more than two crashes during the week, and let *B* be the event that the system crashes at least once. Find a sample space. Then find the subsets of the sample space that correspond to the events *A* and *B*. Then find *P(A)* and *P(B)*.

(10marks)

Number of Crashes	Probability
0	0.6
1	0.3
2	0.05
3	0.04
4	0.01

(b) Assume that the heights in a population of women follow the normal curve with mean $\mu = 64$ inches and standard deviation $\sigma = 3$ inches. The heights of two randomly chosen women are 67 inches and 62 inches. Convert these heights to standard units. (4marks)

OR

14 (a) An electrical engineer has on hand two boxes of resistors, with four resistors in each box. The resistors in the first box are labelled 10 ohms, but in fact their resistances are 9, 10, 11, and 12 ohms. The resistors in the second box are labelled 20 ohms, but in fact their resistances are 18, 19, 20, and 21 ohms. The engineer chooses one resistor from each box and determines the resistance of each. Let *A* be the event that the first resistor has a resistance greater than 10 ohms, let *B* be the event that the second resistor has a resistance less than 19 ohms, and let *C* be the event that the sum of the resistances is equal to 28 ohms. Find a sample space for this experiment, and specify the subsets corresponding to the events *A*, *B*, and *C*. (10marks)

(b) Give the Properties of t- distribution (4marks)

Module 3

15 (a) A hypothesis test is performed of the null hypothesis $H0 : \mu = 0$. The *P*-value turns out to be 0.03. Is the result statistically significant at the 10% level? The 5% level? The 1% level? Is the null hypothesis rejected at the 10% level? The 5% level? The 1% level. (7marks)

(b) Specifications for a water pipe call for a mean breaking strength μ of more than 2000 lb per linear foot. Engineers will perform a hypothesis test to decide whether or not to use a certain kind of pipe. They will select a random sample of 1 ft sections of pipe, measure their breaking strengths, and perform a hypothesis test. The pipe will not be used unless the engineers can conclude that $\mu > 2000$. Assume they test $H0 : \mu \leq 2000$ versus $H1 : \mu > 2000$. Will the engineers decide to use the pipe if *H*0 is rejected? What if *H*0 is not rejected? (7marks)

OR

16 (a) For the following table of data, compute the treatment mean square (MSTr), error mean square (MSE), and F. Find the P-value for testing the null hypothesis that all the means are equal. What do you conclude? (10marks)

Hardness of welds using four different fluxes							
Flux	Sample Values					Sample Mean	Sample Standard Deviation
A	250	264	256	260	239	253.8	9.757
B	263	254	267	265	267	263.2	5.4037
C	257	279	269	273	277	271	8.7178
D	253	258	262	264	273	262	7.4498

(b) Explain the idea of Analysis of Variance (4marks)

Module 4

17. The average percentage ash for five densities of coal particles was measured. The data are presented in the following table:

Density (g/cm3)	Percent ash
1.25	1.93
1.325	4.63
1.375	8.95
1.45	15.05
1.55	23.31

i. Construct a scatterplot of percent ash *(y)* versus density *(x)*. Verify that a linear model is appropriate.

ii. Compute the least-squares line for predicting percent ash from density.

iii. If two coal particles differed in density by 0.1 g/cm3, by how much would you predict their percent ash to differ?

iv. Predict the percent ash for particles with density 1.40 g/cm3.

v. Compute the fitted values.

vi. Compute the residuals. Which point has the residual with the largest magnitude?

vii. Compute the correlation between density and percent ash.

viii. Compute the regression sum of squares, the error sum of squares, and the total sum of squares. (14marks)

OR

18. Using the Hooke's law data in Table, compute the least-squares estimates of the spring constant and the unloaded length of the spring. Write the equation of the least-squares line $y = \beta 0 + \beta 1x$. Estimate the length of the spring under a load of 550 gm. (14marks)

Weight (gm)	Measured Length (cm)

0	12.85
100	12.73
200	13
300	13.03
400	13.06
500	13.11
600	13.34
700	13.18
800	13.31
900	13.87
1000	13.72
1100	14.15
1200	13.89
1300	14.05
1400	14.25
1500	14.2
1600	14.25
1700	14.61
1800	14.43
1900	14.73

Module 5

19 (a) Explain the properties of rotatable of experimental designs (7marks)

(b) What are the characteristics of face-centered cuboidal designs? (7marks)

OR

20 (a) What is meant by orthogonality of a design? Explain (7marks)

(b) Compare different experimental designs (7marks)

****

Syllabus

Module 1: Graphical representation of data (7 Hrs.)

Bar Charts, Histograms, dot plot, Pie Charts, Scatter Plots, Line Charts, Bubble Plots, box and whisker plots, Interval plots, stem and leaf plots.

Descriptive statistics: Mean, Standard Error, Median, Mode, Standard Deviation, Sample Variance, Kurtosis, Skewness, Confidence Level, Quartile, Percentile

Development and interpretation of the above terms in any of the softwares (say, MS Excel, Matlab, R etc.)

Module 2: Probability and statistical distributions (7 Hrs.)

Probability and statistical distributions: Probability, Properties and applications of important statistical distributions such as normal, log-normal and t-distributions, Chi-Square and F distributions

Development and interpretation in any of the softwares (say, MS Excel, Matlab, R etc.)

Module 3: Hypothesis Testing (7 Hrs.)

Hypothesis Testing: Formulation of null and alternate hypotheses, errors in hypothesis Tests, power of hypothesis tests, hypothesis tests on population means and variances

Single factor experiments: Introduction to Analysis of Variance (ANOVA), blocking and randomization

Development and interpretation in any of the softwares (say, MS Excel, Matlab, R etc.)

Module 4: Linear Regression Analysis and Factorial Design of Experiments (7 Hrs.)

Linear Regression Analysis: Matrix approach to linear regression, ANOVA in regression analysis, quantifying regression fits of experimental data.

Factorial Design of Experiments: Need for planned experimentation, factorial design experiments involving two factors, effect of interactions, ANOVA in factorial design, general factorial design, partial factorial designs

Development and interpretation in any of the softwares (say, MS Excel, Matlab, R etc.)

Module 5: Comparison of different experimental design strategies (7 Hrs.)

Comparison of different experimental design strategies: Properties of orthogonal designs, implications of different factorial design models, importance of center runs, central composite design, Box Behnken design, rotatable of experimental designs, face-centered cuboidal designs, comparison of experimental designs

Development and interpretation in any of the softwares (say, MS Excel, Matlab, R etc.)

Text/Reference Books

1. Statistics for Engineers and Scientists, William Navidi, 3rd Edition, Mc Graw Hill
2. Montgomery D. C., Design and Analysis of Experiments, 8th edition, New Delhi: Wiley-India, 2011.
3. Myers R. H., Montgomery D. C. and Anderson C. M., Response Surface Methodology, 3rd edition, New Jersey: Wiley, 2009.
4. Ogunnaike B. A., Random Phenomena, Florida: CRC Press, 2010.

Course Contents and Lecture Schedule

No.	Topic	Hrs of lecture
1	**Module 1**	**7**
1.1	Bar Charts, Histograms, dot plot, Pie Charts	1
1.2	Scatter Plots, Line Charts, Bubble Plots	1
1.3	Box and whisker plots, Interval plots, stem and leaf plots	1
1.4	Descriptive statistics: Mean, Standard Error, Median, Mode	1
1.5	Standard Deviation, Sample Variance, Kurtosis	1
1.6	Skewness, Confidence Level, Quartile, Percentile	1
1.7	Exercise problems	1
2	**Module 2**	**7**
2.1	Introduction to Probability	1
2.2	Introduction to Probability- contd.	1
2.3	Properties and applications of normal distribution	1
2.4	Properties and applications of log- normal distribution	1
2.5	Properties and applications of t-distribution	1
2.6	Properties and applications of Chi-Square distribution	1
2.7	Properties and applications of F distribution	1
3	**Module 3**	**7**
3.1	Hypothesis Testing: Formulation of null and alternate hypotheses	1
3.2	Errors in hypothesis Tests	1
3.3	Power of hypothesis tests	1
3.4	Hypothesis tests on population means and variances	1
3.5	Single factor experiments: Introduction to Analysis of Variance (ANOVA)	1
3.6	Analysis of Variance (ANOVA)- case studies	1
3.7	Blocking and randomization	1
4	**Module 4**	**7**
4.1	Linear Regression Analysis: Matrix approach to linear regression	1
4.2	ANOVA in regression analysis,	1
4.3	Quantifying regression fits of experimental data.	1
4.4	Need for planned experimentation, factorial design experiments involving two factors	1
4.5	Factorial Design of Experiments: effect of interactions,	1
4.6	ANOVA in factorial design,	1
4.7	General factorial design, partial factorial designs	1
5	**Module 5**	**7**
5.1	Properties of orthogonal designs	1
5.2	Implications of different factorial design models	1
5.3	Importance of center runs	1
5.4	Central composite design and Box Behnken design	1
5.5	Rotatable of experimental designs	1
5.6	Face-centered cuboidal designs	1
5.7	Comparison of experimental designs	1

CHT473	FLUIDIZATION ENGINEERING	CATEGORY	L	T	P	CREDIT
		PEC	2	1	0	3

Preamble: This course mainly covers the basic principles of fluidization phenomena and introduces the learner to the fundamental and practical aspects of basic fluidization operations for industrial application.

Prerequisite: Nil

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

CO1	Demonstrate the fluidized bed behaviour and various inductrial application of fluidization.
CO2	Illustrate fluidization regimes and different empirical correlations for pressure drop, hold up, and different flow models.
CO3	Explain the bubbling bed model of fluidized beds and describe the K-L bubbling model.
CO4	Explain the Heat and Mass Transfer in fluidized beds.
CO5	Design a fluidized bed system for different applications.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO 11	PO 12
CO1	3											
CO2	3	3										
CO3	3		3									
CO4	3		3									
CO5	3		3									

Assessment Pattern

	Continuous assessment tests		End Semester Examination
	Test 1	Test 2	
Remember	10	10	10
Understand	20	20	30
Apply	20	20	60
Analyze			
Evaluate			
Create			

Course Level Assessment Questions

Course Outcome 1 (CO1): Demonstrate the fluidized bed behaviour and various industrial application of fluidization.

1. Differentiate between particulate fluidization and aggregative fluidization.
2. Explain the concept of minimum fluidization.
3. Define superficial and terminal velocity of the particles.

Course Outcome 2 (CO2): Illustrate fluidization regimes and different empirical correlations for pressure drop, hold up, and different flow models.

1. List the correlations for the pressure drop requirements across distributors
2. Explain briefly about the Davidson model for gas flow at bubbles
3. Explain the simple two-phase model for bubbling beds

Course Outcome 3 (CO3): Explain the bubbling bed model of fluidized beds and describe the K-L bubbling model.

1. Explain the different types of gas distributors
2. Explain about the two modes of bubble formation above a single orifice into an incipiently fluidized bed with a neat sketch.
3. What are the disadvantages of sintered metal porous plate distributors?

Course Outcome 4 (CO4): Explain the Heat and Mass Transfer in fluidized beds.

1. Describe the mass transfer phenomena between fluid and particles.
2. Explain the gas interchange coefficients between bubble and emulsion
3. Explain and differentiate overall bed coefficient and local coefficient with respect to mass transfer in case of fluidized bed.

Course Outcome 5 (CO5): Design a fluidized bed system for different applications.

1. Explain the kinetic model for porous solids of unchanging size
2. List the information needed for the design of fluidized bed reactors
3. Describe the performance calculations for the Fine Particle Bed

Model Question Paper

Total Pages:

Reg No.:_______________

Name:__________________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SEVENTH SEMESTER B. TECH DEGREE EXAMINATION, -------------

Course Code: CHT473

Course Name: FLUIDIZATION ENGINEERING

Max. Marks: 100 Duration: 3 Hours

PART A

Marks

(Answer all questions; each question carries 3 marks)

1	What is fluidization? Write its importance in chemical process industries.	3
2	Explain the concept of minimum fluidization.	3
3	Define superficial and terminal velocity of the particles.	3
4	List the different types of gas distributors	3
5	Derive a corelation for the initial bubble size above a distributor	3
6	Explain briefly about slug flow	3
7	Define interchange coefficient	3
8	List the minimum requirement for the design of fluidized beds	3
9	Discuss briefly about catalyst deactivation	3
10		3

PART B

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

Module -1

11	Explain the gasification of municipal solid waste using Pyrox process.	14
	OR	
12	Oil of specific gravity 0.9 and viscosity 3mNs/m^2 passes vertically upwards through a bed of catalyst consisting of approximately spherical particles of diameter 0.1 mm and specific gravity 2.6. At approximately what mass rate of flow per unit area of bed will fluidization occur?	14

Module -2

13	What is high velocity fluidization? Mention the significance of pressure drop in turbulent and fast fluidization.	14

OR

14 A perforated plate distributor is to be designed for a fluidized bed. Determine the fraction of open area needed and the relationship between orifice diameter and number of orifices per area. 14

Data

Solids:ps = 2 g/cm^3, ε_{mf} = 0.48, L_{mf} = 3 m

Gas: ρg = 2 X 10^{-3} g/cm^3, μ = 2 X 10^{-4} g/cm · s, u_0 = 60 cm/s

Take d_t = 6 m, Δp_d= 0.3 Δ p_b

Module -3

15 Discuss the coalescence and splitting of bubbles.

OR

16 Discuss the experimental findings for emulsion movement of small and fine particles in a fluidized bed. 14

Module -4

17 Explain and differentiate overall bed coefficient and local coefficient with respect
to mass transfer in case of fluidized bed. 14

OR

18 Describe heat transfer characteristics of liquid-solid fluidized system in brief. 14

Module -5

19 Explain the design of fluidized beds for conversion of solids of unchanging size for a single size particle 14

OR

20 Explain the design of fluidized bed drier for drying of solids

****

Syllabus

Module 1 **(7 hours)**

Introduction: The Phenomenon of Fluidization, Liquid like Behaviour of a F1uidized Bed Comparison with Other Contacting Methods, Advantages and disadvantages of Fluidized bed for Industrial Operations, Fluidization Quality, Selection of Contacting Mode for Given Application.

Industrial application of Fluidized beds: Physical operations - Synthesis reaction, cracking and reforming of hydrocarbons, gasification, carbonization, gas-solid reactions, calcining and clinkering.

Module 2 **(7 hours)**

Fluidization and Mapping of Regimes: Distributors, Gas jets in fluidized beds, Pressure drop in fixed beds, Geldart classification of particles, Gas fluidization with and without entrainment, Mapping of fluidization regimes. Distributor types, Pressure drop requirements across distributors. Design of gas distributors. Power consumption.

Module 3 **(7 hours)**

Analysis of bubble and emulsion phase - Davidson's model, frequency measurements, bubbles in ordinary bubbling bed model for bubble phase and emulsion phase - Experimental findings - Turnover rate of solids - Bubbling bed model for emulsion phase - Interchange coefficient. Flow Pattern of Gas, Heat and Mass Transfer in Fluidized Beds - Flow pattern of gas through fluidized beds - Experimental findings - The bubbling bed model for Gas inter change Interpretation of Gas mixing data.

Module 4 **(7 hours)**

Heat and Mass Transfer between fluid and solid. Experiment findings on Heat and Mass Transfer - Heat and Mass Transfer rates from bubbling bed model. Heat transfer between fluidized beds and surface - Experiment finding theories of bed heat transfer comparison of theories.

Module 5 **(7hours)**

Design for physical operations: Heat transfer, mass transfer, Design of Catalytic Reactors. Design of Non catalytic Gas-solid reactors

Text books

1. Kunii, D. and Levenspiel, O., “Fluidization Engineering”, John Wiley & Sons, Inc.
2. Leva, M., “Fluidization”, McGraw-Hill
3. Davidson, J.F. and Harrison, D., “Fluidized Particle”, Cambridge University Press

References

1. J.H. Perry, Chemical Engineering Hand Book, 3rd Edition.
2. McCabe & Smith, Unit operation of Chemical Engineering

Course Contents and Lecture Schedule

No.	Topic	No. of Lectures
1.	**Module 1**	**7**
1.1	The phenomenon of fluidization, Various forms of contacting of a batch of solids by fluid, circulating fluidized bed, spouted bed	1
1.2	Liquid like behaviour of fluidized bed, contacting schemes of gas fluidized beds, Comparison with other contacting modes	1
1.3	Advantages and disadvantages of fluidized beds for industrial operations, Fluidization Quality, Selection of a contacting mode for a given application	1
1.4	Industrial applications of Fluidized beds: Physical operations, Synthesis reactions	1
1.5	Industrial applications of Fluidized beds: Cracking of hydrocarbons, Combustion and incineration	1
1.6	Industrial applications of Fluidized beds: Carbonization and Gasification, calcinations	1
1.7	Industrial applications of Fluidized beds: Reaction involving solids, Biofluidization	1
2.	**Module 2**	6
2.1	Fluidization without carryover of particles: minimum fluidization velocity, Pressure drop versus velocity diagram, Geldart Classification of particles	1
2.2	Fluidization with carryover of particles: terminal velocity, turbulent and churning fluidization	1
2.3	Pneumatic transport of solids, fast fluidization, Solid circulation systems, The mapping of fluidization regimes	1
2.4	Distributor types: Ideal distributors, Perforated or multi-orifice Plates, Tuyeres and caps, Pipe grid and spargers, Gas entry region of a bed	1
2.5	Gas jets in fluidized beds, Pressure drop across distributors	1
2.6	Design of gas distributors	1
2.7	Power consumption	1
3.	**Module 3**	7
3.1	Single rising bubble: Rise rate of Bubbles, The Davidson model for gas flow at bubbles. Coalescence, Bubble size and bubble frequency	1

3.2	Bubbling fluidized Beds: Experimental findings, Emulsion movement for small, fine and large particles, Emulsion gas flow and voidage	1
3.3	Effect of pressure and temperature on Bed properties, estimation of bed properties like bubble size and bubble growth	1
3.4	Bubble size correlations: Bubble rise velocity	1
3.5	Flow models for bubbling beds: general relationship. Simple two phase model, K-L Model	1
3.6	Dispersion of gas in beds, Gas interchange between bubble and emulsion, Single bubble method, Bubbling bed methods	1
3.7	Experimental findings on Interchange coefficients, Estimation of gas interchange coefficients	1
4.	**Module 4**	8
4.1	Mass transfer: experimental, Interpretation of mass transfer coefficients	1
4.2	Effect of Adsorption on Interchange coefficients, Heat transfer from the bubbling fluidized model	1
4.3	Heat transfer: Experimental, Interpretation of heat transfer	1
4.4	Experimental findings: heat transfer coefficient, vertical and horizontal tube	1
4.5	Fast fluidization and solid circulation systems	1
4.6	Theoretical studies: Fixed and incipiently fluidized beds	1
4.7	Bubbling beds- h at a heat exchanger surface	1
5.	**Module 5**	7
5.1	Design for physical operations: Information needed for design, Heat transfer-batch operations	2
5.2	Heat transfer-Continuous operations, Heat loss to surroundings	1
5.3	Mass transfer: Batch operations, Continuous operations	1
5.4	Design of catalytic reactors- Bench scale reactors, Pilot plant reactors, Design considerations	1
5.5	Deactivating catalysts	1
5.6	The Design of Noncatalytic Gas-solid reactions, Kinetics for the conversion of solids	1
5.7	Conversion of solids of unchanging size	1

SEMESTER VII

OPEN ELECTIVE

CHT415	ENERGY TECHNOLOGY AND ENERGY MANAGEMENT	CATEGORY	L	T	P	CREDIT
		OEC	2	1	0	3

Preamble: This course provides basic knowledge on various energy resources, conversion processes and energy management. Students may gain knowledge on Energy Auditing, Energy conservation, Waste Heat Recovery, Maintenance of Energy Systems.

Prerequisite: Nil

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

CO 1	Identify and explain energy resources and energy conversion processes.
CO 2	Explain energy conversion from solar, ocean and wind energy.
CO 3	Explain energy conversion from biomass and fuel cells.
CO 4	Explain energy policies, energy management and audit.
CO 5	Apply the energy conservation methods in various fields of chemical process industries, commercial and residential buildings.

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	10	10	30
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): Identify and explain energy resources and energy conversion processes.
1. List out the energy conversion devices.
2. Classify different energy resources.
3. Explain briefly on conventional plants for energy conversion.

Course Outcome 2 (CO2): Explain energy conversion from solar, ocean and wind energy.
1. Describe on solar thermal systems.
2. Explain the working of pyranometer.
3. Explain the types of windmills for the conversion of wind energy.

Course Outcome 3(CO3): Explain energy conversion from biomass and fuel cells.
1. Explain the working of a fuel cell and discuss the classification.
2. Explain the working of Microbial fuel cell.
3. Describe the energy conversion methods from biomass.

Course Outcome 4 (CO4): Explain energy policies, energy management and audit.
1. What are the energy policies employed in India?
2. Discuss about energy audit.
3. Describe various energy management control systems.

Course Outcome 5 (CO5): Apply the energy conservation methods in various fields of chemical process industries, commercial and residential buildings.
1. Explain the energy conservation methods employed in chemical process industries.
2. Discuss the use of cogeneration as an energy conservation tool.
3. Describe with a neat diagram on waste heat recovery in industries.

Model Question Paper

QP CODE: **PAGES: 2**

Reg No: ______________
Name: __________________________

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

Course Code: CHT415

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

ENERGY TECHNOLOGY AND ENERGY MANAGEMENT

PART – A

Answer All the Questions (10 x 3 = 30)

1. Differentiate between conventional and nonconventional energy resources.
2. List out the governing equations in magneto hydrodynamics.
3. Describe the principle of tidal energy conversion.
4. List out the application of solar energy in India.
5. Explain the basic principle of microbial fuel cell.
6. List out the methods for conversion of energy from biomass.
7. What are the energy policies in India?
8. What is energy audit?
9. Explain the principle of energy conservation.
10. What are the energy conservation measures?

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

Module 1

11. List out the conventional and nonconventional energy resources. Describe briefly the production of energy from any three conventional and nonconventional energy resources.

OR

12. Analyse the energy situation in India and give your suggestions for a better energy independence.

Module 2

13. With a neat diagram explain the working of open and closed cycle ocean thermal energy conversion systems.

OR

14. Explain different wind energy conversion systems.

Module 3

15. (a) Describe the principle and working of solid oxide fuel cell with a neat diagram.

(b) Explain the process of energy conversion from biomass using pyrolysis with the help of neat flow diagram.

OR

16. Explain thermochemical and biochemical methods of biomass conversion to various forms of energy.

Module 4

17. Discuss the present Indian energy scenario and give your suggestions for a better energy sustainability

OR

18. Discuss different types and objectives of an energy audit.

Module 5

19. Explain the energy conservation opportunities in residential buildings.

OR

20. Describe ccombined cycle power generation with a neat diagram.

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Syllabus

Module 1: Introduction to Energy Conversion **(7 Hrs.)**

Energy resources, Energy conversion processes and devices – Energy conversion plants – Conventional - Thermal, Hydro, Nuclear fission , and Non – conventional – Solar -Wind- Biomass- Fuel cells- Magneto Hydrodynamics and Nuclear fusion. Energy from waste, Energy plantation.

Module 2: Non-conventional energy sources **(7 Hrs.)**

Solar energy- Solar thermal systems- Flat plate collectors- Focusing collectors- Applications of solar energy in India - Instruments to measure solar radiation- Pyranometer – Pyrheliometer. Ocean wave energy conversion- Ocean thermal energy conversion- Tidal energy conversion- Wind energy- Types of windmills- Wind electric power generation- Wind power in India.

Module 3 : Biomass energy resources **(7 Hrs.)**

Thermochemical and Biochemical methods of biomass conversion, 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.

Module 4: Energy management and Energy audit **(7 Hrs.)**

Energy Scenario – Global and Indian –Impact of Energy on economy, development and environment, Energy policies. Energy Management – Definitions and significance – Objectives – Characterising of energy usage – Energy Management program – Energy strategies and energy planning. Energy Audit – Types and Procedure – Optimum performance of existing facilities – Energy management control systems – Computer applications in energy management.

Module 5: Energy conservation **(7 Hrs.)**

Energy conservation – Principles – Energy conservation technologies – Cogeneration – Waste heat recovery – Combined cycle power generation – Energy Conservation Opportunities – Electrical ECOs – Thermodynamic ECOs in chemical process industry – ECOs in residential and commercial buildings – Energy Conservation Measures

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.
4. Amlan Chakrabarti, Energy Engineering and Management, Prentice Hall India, 2011.

5. Eastop T. D. and D. R. Croft, Energy Efficiency for Engineers & Technologists, Longman, 1990.

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
7. Albert Thumann P. E. and W. J. Younger, Handbook of Energy Audits, Fairmont Press, 2008.
8. Doty S. and W. C. Turner, Energy Management Hand book, 7/e, Fairmont Press, 2009.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Module 1**	**7**
1.1	Energy resources, Energy conversion processes and devices	1
1.2	Energy conversion plants – Conventional - Thermal, Hydro, Nuclear fission	2
1.3	Energy conversion plants – Non – conventional – Solar -Wind- Biomass-Fuel cells-	2
1.4	Energy conversion plants –Magneto Hydrodynamics and Nuclear fusion.	1
1.5	Energy from waste, Energy plantation.	1
2	**Module 2**	**7**
2.1	Solar energy- Solar thermal systems- Flat plate collectors- Focusing collectors- Aapplications of solar energy in India.	2
2.2	Instruments to measure solar radiation- Pyranometer – Pyrheliometer.	1
2.3	Ocean wave energy conversion- Ocean thermal energy conversion- Tidal energy conversion-	2
24	Wind energy- Types of windmills	1
2.5	Wind electric power generation- Wind power in India.	1
3	**Module 3**	**7**
3.1	Biomass energy resources- Thermochemical and Biochemical methods of biomass conversion.	2
3.2	-Fuel cells- Alkaline fuel cell- Phosphoric acid fuel cell	2
3.3	Molten carbonate fuel cell, Solid oxide fuel cell.	1
3.4	Solid polymer electrolyte fuel cell	1
3.5	Basic concepts of Microbial fuel cell	1
4	**Module 4**	**7**
4.1	Energy Scenario – Global and Indian –Impact of Energy on economy, development and environment.	1
4.2	Energy Management – Definitions and significance – Objectives	1
4.3	Characterising of energy usage – Energy Management program	1
4.4	Energy policies. – Energy strategies and energy planning.	1
4.5	Energy Audit – Types and Procedure – Optimum performance of existing facilities	2
4.6	Energy management control systems – Computer applications in energy	1

	management.	
5	**Module 5**	**7**
5.1	Energy conservation – Principles -Energy conservation technologies – Cogeneration	2
5.3	Waste heat recovery – Combined cycle power generation	1
5.4	Energy Conservation Opportunities – Electrical ECOs	1
5.5	Thermodynamic ECOs in chemical process industry	1
5.6	ECOs in residential and commercial buildings	1
5.7	Energy Conservation Measures	1

CHT425	PETROLEUM RESOURCES AND PETROCHEMICALS	CATEGORY	L	T	P	CREDIT
		OEC	2	1	0	3

Preamble: This course introduces the students to the fundamentals of oil and natural gas engineering like the origin and formation of Petroleum, and petroleum geology. Students will get an understanding about the various exploration techniques, oil well drilling and its completion. The course also introduces the students to geographic distribution of unconventional hydrocarbon resources and methodology to produce these reserves. The course also provides knowledge to learn scientific and technological principles of organic synthesis and related unit processes.

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, drilling and production techniques practiced in the oil wells.
CO 3	Outline the geology, origin, reservoir characteristics and production technology of unconventional oil.
CO 4	Outline the geology, origin, reservoir characteristics and production technology of unconventional gases.
CO 5	Understand various petrochemical feedstocks and summarize the production of various petrochemicals.

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

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
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 the reservoir rock.
2. Classify various types of reservoir rocks.
3. Differentiate between absolute permeability and effective permeability.

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. Explain main types of logs used in well logging

Course Outcome 3 (CO3): 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

Course Outcome 4 (CO4): Outline 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 hydraulic fracturing technique with a neat sketch for the production of shale gas

Course Outcome 5 (CO5): Understand various petrochemical feedstocks and summarize the production of various petrochemicals.

1. Describe the production of PVC and Polypropylene.
2. Explain manufacturing of Caprolactum from Benzene with a neat process flow diagram

Model Question Paper

QP CODE: **PAGES: 3**

Reg No: ______________

Name: ___________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SEVENTH SEMESTER B. TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: CHT425

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

PETROLEUM RESOURCES AND PETROCHEMICALS

PART – A

Answer All the Questions (10 x 3 = 30)

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 Explain the formation of tar sand.

6 Outline the composition of oil shales.

7 Explain biogenic and thermogenic coal bed methane formation.

8 Differentiate between shale gas and tight gas.

9 List six major petrochemical products and their applications

10 Properties poly ethylene.

PART – B

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

Module 1

11		Outline the migration and accumulation of hydrocarbons from source rock to reservoir rock.	14
12	a	Classify various types of reservoir rocks.	6
12	b	Explain magnetic and seismic method for the exploration of petroleum.	8

Module 2

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

Module 3

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

Module 4

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

Module 5

19		Describe the production of ethylene, propylene, and butadiene by naphtha cracking.	14
20		Explain manufacturing of Caprolactum from Benzene with a neat process flow diagram.	14

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Syllabus

Module 1: Fundamentals of petroleum geology (7 hrs)

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.

Module 2: Introduction to exploration, well drilling and production (8 hrs)

Petroleum Exploration, 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: Introduction to non-conventional oil (7 Hrs.)

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. Heavy oil: Introduction, geology, origin and occurrence worldwide, composition and production technologies.

Module 4: Introduction to non-conventional gas (7 Hrs.)

Introduction, present status, formation and properties of coal bed methane, natural gas hydrate, tight gas sands, shale gas. Shale Gas: Exploration, Production-hydrofracking, Drilling and completion.

Module 5: Introduction to Petrochemicals (6 Hrs.)

Petrochemical Industries & their feed stocks, Major Petrochemical products and their applications. First, Second and Third generation petrochemical products, Production of Acetylene, Ethylene and Propylene by steam cracking of Naphtha, Manufacture of Caprolactum from Benzene, Manufacture of Poly ethylene, P.V.C, Poly propylene.

Text /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
9. Advanced Petrochemicals: Dr. G. N. Sarkar, Khanna Publishers
10. A Text on Petrochemicals: B.K.B. Rao, Khanna Pub.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Module 1 (7 Hrs.)**	
1.1	Introduction, origin, formation, geological occurrence and characteristics of oil and natural gas.	2
1.2	Source Rocks, Reservoir Rocks, and Cap rocks: Definition, Characteristics, Classification and nomenclature.	2
1.3	Concept of Shale oil, Reservoir Properties.	1
1.4	Hydrocarbon migration.	2
2	**Module 2 (8 Hrs.)**	
2.1	Petroleum Exploration, Well logging: Logging Terminology-Borehole environment.	2
2.2	Major components of well logging unit and logging setup- Classification of well logging methods.	2
2.3	Well Drilling: cable tool drilling, rotary drilling, types of drilling units, and types of production units.	2
24	Well completion.	1
2.5	Production methods.	1
3	**Module 3 (7 Hrs.)**	
3.1	Shale oil: Introduction, geology, origin, types of oil shales, and occurrence worldwide, Kerogen and its composition, production technologies.	3
3.2	Tar Sand: Introduction, geology, origin and occurrence worldwide, composition, resources.	2
3.3	Heavy oil: Introduction, geology, origin and occurrence worldwide, composition and production technologies.	2
4	**Module 4 (7 Hrs.)**	
4.1	Introduction, present status, formation and properties of coal bed methane, natural gas hydrate, tight gas sands, shale gas.	3
4.2	Shale Gas: Exploration, Production-hydrofracking, Drilling and completion.	2
4.3	Shale Gas: Drilling and completion.	2
5	**Module 5 (6 Hrs.)**	
5.1	Petrochemical Industries & their feed stocks.	1
5.2	Major Petrochemical products and their applications.	1
5.3	First, Second and Third generation petrochemical products.	1
5.4	Production of Acetylene, Ethylene and Propylene by steam cracking of Naphtha.	1
5.5	Manufacture of Caprolactum from Benzene.	1
5.6	Manufacture of Poly ethylene, P.V.C, Poly propylene.	1

CHT435	PROCESS SAFETY ENGINEERING	CATEGORY	L	T	P	CREDIT
		OEC	2	1	0	3

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

Prerequisite: Nil

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

CO 1	Impart the basic concept of process safety engineering, accidents and management.
CO 2	Apply the chemical engineering fundamentals in the chemical hazards prevention techniques.
CO 3	Identify various hazards associated with chemical process industries using various techniques.
CO 4	Develop an understanding about quantitative risk analysis in industries and emergency planning.
CO 5	Analyse the significance of inherent, passive, active and human factors in safety.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3					2	2					
CO 2	3					2	2					
CO 3	3					2	2					
CO 4	3					2	2					
CO 5	3					2	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): Impart the basic concept of process safety engineering, accidents and management.

1. List the type and classification of accidents.
2. Significance of work permit systems.
3. Define the components of a MSDS; demonstrate the need in updating its contents.

Course Outcome 2 (CO2): Apply the chemical engineering fundamentals in the chemical hazards prevention techniques.

1. List the classification of fire
2. Define fire pyramid and review its application in fire extinguishing
3. Describe BLEVE, Toxic release.

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

1. List the various hazard identification techniques
2. Explain the methodology of HAZOP.
3. Significance of Fault tree analysis.

Course Outcome 4 (CO4): Develop an understanding about quantitative risk analysis in industries and emergency planning.

1. Methodology of QRA
2. Illustrate the probit equations.
3. Describe the need of emergency planning in a process industry

Course Outcome 5 (CO5): Analyse the significance of inherent, passive, active and human factors in safety.

1. Tools for inherent safety
2. Human factors in safety
3. List some salient features in Factories Act 1948, Incorporating safety provisions.

Model Question Paper

QP CODE: **PAGES:2**

Reg No:______________

Name :______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SEVENTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: CHT435

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

PROCESS SAFETY ENGINEERING

(2019-Scheme)

PART A

(Answer all questions, each question carries 3 marks)

1. What are the major elements of PSM?
2. Define accident.
3. Write the significance of flammability diagram.
4. Distinguish between Deflagration and detonation.
5. Differentiate between FTA and ETA.
6. Write the salient features of FMEA.
7. Write the significance of SIL.
8. What are the objectives of emergency plan?
9. Differentiate between inherent safety and add on safety.
10. What are the salient features of gas cylinder rules? (10x3=30 marks)

PART B

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

MODULE 1

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) Explain the major hazard control strategy in process industries. (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 3

15. a) Explain the methodology of fault tree analysis.

b) 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. (7+7=14 marks)

16. a) Differentiate between HAZID and HAZAN with suitable examples.

b) Explain the salient features of HAZOP. (7+7=14 marks)

MODULE 4

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) Discuss the significance of Probit equation. Write the probit equation for thermal effects.

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

(7+7 = 14 marks)

MODULE 5

19.a) Explain the concept of inherent safety. Describe the various tools for assessing inherent process safety.

b) Write the objectives, scope and techniques of Reliability engineering.

(8+6=14 marks)

20.a) Discuss the significance of human factors in safety.

b) Differentiate between individual risk and societal risk with examples.

(8+6 =14 marks)

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Syllabus

Module 1 **(8 hours)**

Introduction to Process safety: Concept of process safety engineering and process safety management (PSM). Hazard – Hazard triangle, Classification of hazards- physical hazards, Electrical hazards.

Accidents – types, cost of accidents. Review of industrial accidents – Bhopal, Flixborough and Seveso. Material safety data sheet (MSDS)**.** Work permit system, Personal Protective Equipments (PPE).

Module 2 **(7 hours)**

Chemical Hazards:- Fire triangle, LFL, UFL, Types fire- Pool fire, jet fire, Flash fire and Fire ball. Fire prevention techniques in process industry. Flammability diagram- construction and application.

Explosion:- Deflagration, Detonation, UVCE, BLEVE and Dust explosion. Prevention techniques for explosion.

Toxic release: - Types of exposure, Measure of toxicity, Types of toxic effects. Run away reactions and their mitigation.

Module 3 **(7 hours)**

Hazard identification techniques: - Dow fire, explosion & Toxicity index, Chemical exposure index, Hazard and operability study (HAZOP), What if analysis, Failure mode and effect analysis (FMEA), Fault tree analysis (FTA), Event tree analysis (ETA), Layer of protection analysis (LOPA).

Module 4 **(7 hours)**

Risk;- Quantitative risk analysis (Methodology only). Probit equations, FN curves, Individual risk, societal risk, risk indices. Safety integrity level (SIL).

Emergency planning – Objective of emergency plan, Onsite and Offsite emergency plan. Mock drill.

Regulatory Bodies: - National safety council, OSHA, Loss prevention association, PESO, NEBOSH.

Module 5 **(6 hours)**

Inherent Safety – Inherent, passive and active safety systems, Tools for inherent safety. Human factors in safety. Basic principles of reliability engineering, ways of improving process reliability. Security in process industries (fundamentals only).

Major statutory regulations regarding safety- Gas cylinder rules, SMPV rules, MSIHC rules.

Text/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. Daniel A. Crowl/ Joseph F. Louvar, Chemical Process Safety Fundamentals with applications, Prentice Hall international series, Second edition.
3. K.S.N Raju,Chemical Process Industrial safety, McGraw Hill, 2014.
4. Ralph King, Safety in the Process Industries, Butterworth-Heinemann.
5. R.K.Jain & Sunil S Rao, Industrial Safety, Health and Environment Management Systems, Khanna Publishers, Fourth Edition,2000
6. Encyclopaedia of Occupational Health & Safety, International labour Office, Geneva, 2012
7. Frank P. Lees- "Loss Prevention in Process Industries" ,Vol.1,2&3,Second Edn, Butterworth-Heinemann.1996
8. Guidelines for Hazard Evaluation Procedure. Centre for Chemical Process Safety.AICHE,1992
9. 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	**Module 1**	**8**
1.1	Concept of process safety engineering and process safety management (PSM)	2
1.2	Hazard – Hazard triangle, Classification of hazards- physical hazards, Electrical hazards.	2
1.3	Review of Industrial Accidents. Major Chemical Industry Accidents. Cost of accidents.	2
1.4	Material safety data sheet. Work permit system, , Personal Protective Equipments (PPE)	2
2	**Module 2**	**7**
2.1	Types of Fire-Pool fire, Jet fire, Flash fire, LFL, UFL	1
2.2	Fire prevention techniques in process industry, Flammability Diagram	2
2.2	Explosion-UVCE, BLEVE, Prevention techniques	1
2.3	Toxic release: - Types of exposure, Measure of toxicity, Types of toxic effects.	2
2.4	Run away reactions and their mitigation	1
3	**Module 3**	**7**
3.1	Dow fire, explosion & Toxicity index, Chemical exposure index.	2
3.2	Hazard and operability study (HAZOP), What if analysis, Failure mode and effect analysis (FMEA).	2
3.3	Fault tree analysis (FTA), Event tree analysis (ETA), Layer of protection analysis (LOPA).	2
3.4	Problems solving.	1
4	**Module 4**	**7**
4.1	Quantitative risk analysis (Methodology only).	1
4.2	Probit equations, FN curves, Individual risk, societal risk, risk indices. Safety integrity level (SIL)	3
4.3	Objective of emergency plan, Onsite and Offsite emergency plan. Mock drill.	1
4.4	Regulatory Bodies: - National safety council, OSHA, Loss	2

	prevention association, PESO, NEBOSH.	
5	**Module 5**	**6**
5.1	Inherent, passive and active safety systems, Tools for inherent safety.	1
5.2	Human factors in safety. Basic principles of reliability engineering, ways of improving process reliability. Security in process industries (fundamentals only).	3
5.3	Major statutory regulations regarding safety- Gas cylinder rules, SMPV rules, MSIHC rules.	2

CHT445	PIPING AND PIPELINE DESIGN FOR PROCESS INDUSTRIES	CATEGORY	L	T	P	CREDIT
		OEC	2	1	0	3

Preamble: This course aims to impart the basics of piping. It covers the basic terminologies, codes and standards, materials used for piping, that any engineer working in a process plant needs to deal with. Head loss calculations in pipelines is also carried out. Another area of focus is to prepare the students to read and develop P& ID diagrams.

Prerequisite: Fundamentals of fluid mechanics.

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

CO1	Explain the materials, dimensions, codes and standards used in piping.
CO2	Identify the components of a piping system and select the suitable fittings/valves/pumps for a given application.
CO3	Calculate the frictional head losses in pipelines.
CO4	Explain the criteria and components used in piping design for process industries and describe the methods for flow measurement and protection of pipelines.
CO5	Develop and interpret Piping & Instrumentation Diagram for process industries.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO4	PO5	PO 6	PO 7	PO 8	PO9	PO 10	PO11	PO 12
CO 1	3											
CO 2	3											
CO 3	3	3										
CO 4	3											
CO 5	3									3		

Assessment Pattern

Blooms'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 each 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 explain the materials, dimensions, codes and standards used in piping.

1. Differentiate between tubes and pipes.
2. Classify types of insulation used in piping based on their purpose giving 2 examples for the materials used in each type.
3. List any 5 mechanical properties considered during selection of material for piping components.

Course Outcome 2 (CO2): Identify the components of a piping system and select the suitable fittings/valves/pumps for a given application.

1. List out the various piping system components.
2. Distinguish between Isolation valves and Regulation valves giving 3 examples for each.
3. Select a suitable pump for handling slurries and explain its working with a neat sketch.

Course Outcome 3 (CO3): Calculate the frictional head losses in pipelines.

1. Calculate the frictional head loss for a commercial steel pipe with the following characteristics: length L = 30.48 m; inside diameter d = 0.0526 m; pipe roughness ε = 0.000045 m; steady liquid flow rate Q = 9.085 m^3/h; liquid dynamic viscosity μ = 0.01 Pa.s; liquid density ρ = 1200 kg/m^3.
2. A horizontal pipe, 10 cm in diameter is joined by sudden enlargement to a 15 cm diameter pipe. Water is flowing through it at the rate of 2 m3/min. Find the loss of head due to abrupt expansion and the pressure difference in the two pipes.

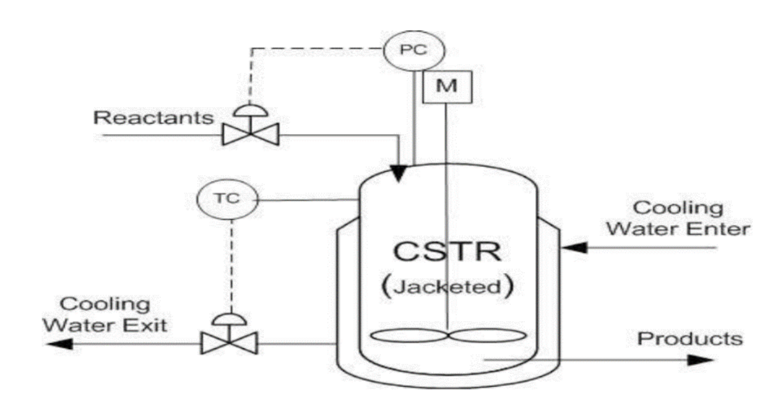
3. Describe equivalent pipe analysis. List out the parameters required to prepare an equivalent pipe structure.

Course Outcome 4 (CO4): Explain the criteria and components used in piping design for process industries and describe the methods for flow measurement and protection of pipelines.

1. Explain the working principle of any two types of steam traps with the help of neat sketches.
2. Explain the principle of cathodic protection of underground pipelines.
3. Give the classification of pipe supports.

Course Outcome 5 (CO5): Develop and interpret Piping & Instrumentation Diagram for process industries

1. Illustrate how a Flow Transmitted located near the process in the field is represented on a P&I Diagram.
2. List out the components shown in the following diagram. Describe the process being



controlled.
3. Use P&ID to describe a basic temperature control loop for a reactor.

Model Question Paper

QP CODE: **PAGES:3**

Reg No.:_______________

Name:__________________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SEVENTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: CHT445

Course Name: PIPING AND PIPELINE DESIGN FOR PROCESS INDUSTRIES

Max. Marks: 100 Duration: 3 Hours

PART A

(Answer all questions; each question carries 3 marks)

		Marks
1	Define Schedule number, nominal bore, and nominal diameter.	3
2	Describe the main objectives of piping insulation.	3
3	With help of examples differentiate on/off and control valves.	3
4	Define NPSH. Differentiate between NPSHA and NPSHR.	3
5	List out the major components of a pipeline.	3
6	Explain dryness fraction of steam. Describe its significance in steam transportation.	3
7	Pipe can be joined in several ways. List any 6 types of pipe joints.	3
8	Certain pipeline carries an abrasive slurry. Select a suitable valve for this application and give justification.	3
9	Describe the significance of P&ID diagrams in process industries.	3
10	Describe the elements in a basic control loop.	3

PART B

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

Module -1

11	a)	Explain the criteria of selection of materials for pipes.	7
	b)	Classify types of insulation used in piping based on their purpose giving 2 examples for the materials.	7
12	a)	Explain the significance of Codes and Standards in piping. List any four IS standards commonly used by piping engineers mentioning their area of application.	7
	b)	List out the different types of metallic pipes used in process industries. Also mention the application of each type.	7

Module -2

13 a) Explain the classification of pumps with examples. 8

b) Differentiate globe and gate valves. 6

14 a) Give the applications of the following types of pipe fittings 6

a). Elbows

b). Tees

c). Stub ends

d). Swage Nipples

e). Reducers

f). Couplings

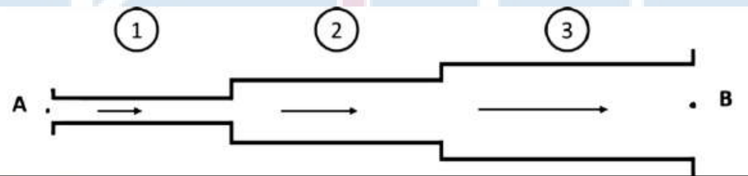
b) With a neat schematic diagram explain working of a lobe pump. 8

Module -3

15 a) Water flows through a horizontal pipe of 20cm diameter which expands suddenly to a 30cm diameter pipe. If the flow rate is 0.5 m^3/s, find the head loss due to sudden enlargement. 10

b) Explain the effect of roughness on pressure drop in a pipeline. 4

16 a) Given is a three-pipe series system. The total pressure drop is p_A-p_B= 150kP and the elevation drop is Z_A-Z_B = 5m. The pipe data are 10



Pipe	L,m	d, cm	ε , mm
1	100	8	0.24
2	150	6	0.12
3	80	4	0.20

The fluid is water, ρ = 1000 kg/m^3 and viscosity μ= 1.02 × 10^{-3} Pas. Calculate the flow rate in m^3/s through the system.

b) Explain the effect of sudden expansion and contraction on head loss in a pipeline. 4

Module -4

17 a) With help of a typical steam circuit diagram, explain any five components of a steam distribution system. 10

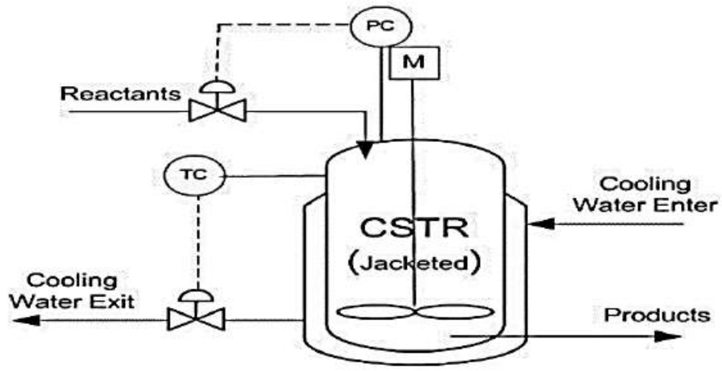
b) Define pigging in pipelines. Explain the purpose of pigging. 4

18 a) Give the classification of steam traps. With the help of schematic diagrams explain working of any two steam traps. 10

b) Give the classification of flow meters used in pipelines. 4

Module -5

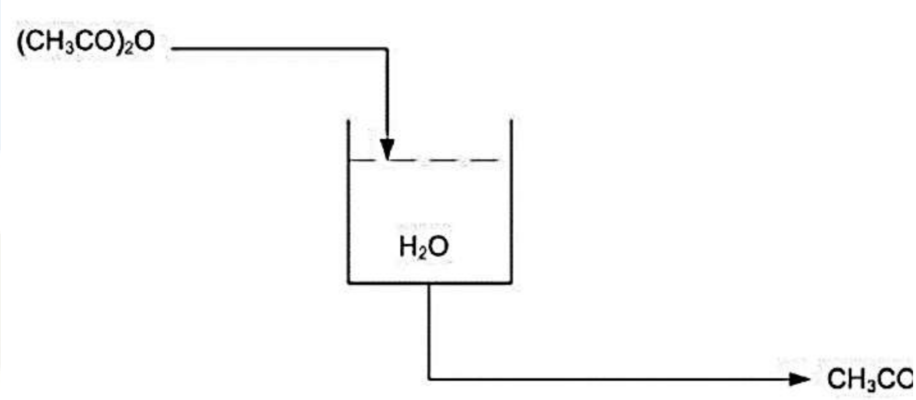
19 a) List out the components shown in the following diagram. Describe 9.5



the process being controlled.

b) Illustrate how a Flow Transmitted located near the process in the field is represented on a P&I Diagram. 4.5

20 a) Basic Flow Diagram of reaction of Acetic Anhydride with water to produce Acetic Acid is given below. 14



Devise a suitable control loop to maintain the liquid level in the reactor and prepare a P&ID diagram

Syllabus

Module 1: Classification, codes and materials for pipes (7 Hrs.)

Classification of pipes and tubes, Schedule numbers, Common piping abbreviations, Major organizations for standards, IS and BS codes for pipes used in process industries, Piping materials and selection. Pipeline insulation, pipes for newtonian flow.

Module 2: Piping components (9 Hrs.)

Pipe connection and fittings, Type of Fittings - elbows, weld tee, stub in, couplings, reducers, weld cap, screwed and socket welded fittings, Pipe nipples, flanged fittings and use of fittings, Flange - Types, Gaskets, bolts and nuts.

Valves: Types of valves, selection criteria of valves for various systems.

Pumps: Types of pumps, NPSH requirement, pump location, pump piping, pump piping support.

Module 3: Frictional head losses for flow of Newtonian fluids through pipes (7 Hrs.)

Frictional head losses for flow of Newtonian fluids through pipes, effect of surface roughness, Moody Diagram, effect of sudden expansion, sudden contraction and fittings.

Equivalent pipes; pipes in series, parallel, series-parallel.

Module 4: Piping design, Pipeline protection and flow measurement (7 Hrs.)

Piping design: Basic principles of piping design, Working pressure, Pipe Joints and supports, pipe installations, overhead installations.

Process steam piping, steam traps: their characteristics, selection and application, selection and determination of steam – pipe size.

Components of pipelines, Pipeline protection, Instrumentation, pigging (Definition and Purpose): Pipeline coating, Cathodic protection, Internal corrosion, Flow meters, Sensors.

Module 5: Piping and Instrumentation Diagram (P&ID) (5 Hrs.)

Piping and Instrumentation Diagram (P&ID): Basic Control loops, Purpose of P&ID in process industries, P&ID Symbols, Line Numbering, Valve Numbering, Equipment Identification, Abbreviations.

Text Books:

1. Bhasin, S.D." Project Engineering of Process Plants", Chemical Engineering Education Development Centre, IIT Madras, 1979

2. Davidson, P.J & West, T. F.” Services for the Chemical Industry”, Pergamon Press, Oxford, 1968.
3. Henry Liu, “Pipeline Engineering”, Lewis Publishers.

References:

1. F.C. Vibrandt and C.E. Dryden, “Chemical Engineering Plant Design”, McGraw Hill, Fifth Edition.
2. Frank M. White, Fluid Mechanics, McGraw Hill.
3. Jack Broughton; Process utility systems; Institution of Chem. Engineers, U.K.
4. M.S. Peters and Timmerhaus, “Plant design and Economics for Chemical Engineers”, Mc Graw Hill 3rd Edition.
5. Roger Hunt and Ed Bausbacher, “Process Plant layout and Piping Design” PTR Prentice-Hall Inc.
6. Cremer, H.W & Watkins, S.B , “Chemical Engineering Practice”, Vol.10, Butterworths, London, 1960

Course contents and lecture schedule

No	Topic	No of Lectures
1	**Module 5**	**7**
1.1	Classification of pipes and tubes	1
1.2	Schedule numbers, Common piping abbreviations,	1
1.3	Major organizations for standards, IS and BS codes for pipes used in process industries,	1
1.4	Piping materials and selection	2
1.5	Pipeline insulation, pipes for newtonian flow	2
2	**Module 2**	9
2.1	Pipe connection and fittings,	1
2.2	Type of Fittings - elbows, weld tee, stub in, couplings, reducers, weld cap, screwed and socket welded fittings, ,	2
2.3	Pipe nipples, flanged fittings and use of fittings, Flange -Types,	1
2.4	Gaskets, bolts and nuts	1
2.5	Valves: Types of valves, selection criteria of valves for various systems.	1
2.6	Pumps: Types of pumps, NPSH requirement, pump location, pump piping, pump piping support.	3
3	**Module 3**	**7**
3.1	Bernoulli's equation with friction correction factor (only final expression), Equation for pressure drop/ head loss in terms of friction factor (no derivation)	2
3.2	Surface roughness, Moody Diagram	1
3.3	Effect of sudden expansion, sudden contraction and fittings	2
3.4	Equivalent pipes; pipes in series, parallel, series-parallel.	2
4	**Module 4**	**7**
4.1	Piping design: Basic principles of piping design, Working pressure	1
4.2	Pipe Joints and supports, pipe installations, overhead installations	1
4.3	Process steam piping, steam traps: their characteristics, selection and application, selection and determination of steam – pipe size	2
4.4	Components of Pipelines, Pipeline protection, Instrumentation, pigging (Definition and Purpose): Pipeline coating, Cathodic protection, Internal corrosion	2
4.5	Flow meters, Sensors	1
5	**Module 5**	**5**
5.1	Basic Control loops, Purpose of P&ID in process industries	1
5.2	P&ID Symbols	1
5.3	Line Numbering, Valve Numbering,	1
5.4	Equipment Identification, Abbreviation	2

SEMESTER VII

MINOR

CHD481	MINI PROJECT	CATEGORY	L	T	P	CREDIT
		PWS	0	0	3	4

Preamble: Mini 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;

CO1	Identify and synthesize problems and propose solutions to them.
CO2	Prepare work plan and liaison with the team in completing as per schedule.
CO3	Validate the above solutions by theoretical calculations and through experimental
CO4	Write technical reports and develop proper communication skills.
CO5	Present the data and defend ideas.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3					3	3		2
CO2	3			3				3	3	3	3	
CO3	3	3	3	3	3					3		
CO4					3			3	3	3		1
CO5	3	3	3	3				3		3	3	1

*1-slight/low mapping, 2- moderate/medium mapping, 3-substantial/high mapping

Continuous Internal Evaluation Pattern:

Sl. No.	Level of Evaluation	Marks
1	Interim evaluation by the committee	**20**
2	Project Guide	**30**
3	Final Seminar evaluation by the committee	**30**
4	The report evaluated by the evaluation committee	**20**
	Total	**100**
	Minimum required to pass	**50**

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

SEMESTER VII

HONOURS

CHT495	PROCESS INTEGRATION	CATEGORY	L	T	P	CREDIT
		VAC	3	1	0	4

Preamble: The objective of this course is to impart the knowledge of systematic methods for the material and energy integration of chemical process industries. In this course, particular emphasis will be given to various techniques for placement and integration of heat exchangers, mass exchangers, reactors and distillation columns.

Prerequisite: Knowledge in unit operations and unit processes

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

CO 1	Optimize the heating and cooling utility requirement
CO 2	Design heat exchanger network using pinch technology
CO 3	Modify processes for minimization of raw material and waste generation.
CO 4	Select suitable reactors for energy efficient operation.
CO 5	Analyze energy optimal integration solutions for distillation columns

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	PO11	PO12
CO 1		3	3									
CO 2	3		3								2	
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): Calculate the minimum heating and cooling utility requirement

1. Consider the following data

FCp (kW/C)	1.5	2	2.7	1.5	0.4
Initial Temperature (^{o} C)	170	45	20	80	160
Target Temperature (^{o} C)	60	30	132	140	195

Choose 10 ^{o} C as minimum temperature difference and draw the grand composite curve.

2. Consider the following data. Choose 10 ^{o} C as minimum temperature difference and calculate minimum heating and cooling utility

FCp (kW/C)	1.5	2	2.7	1.5	0.4
Initial Temperature (^{o} C)	170	45	20	80	160
Target Temperature (^{o} C)	60	30	132	140	195

3. Discuss on areas of application of process integration

Course Outcome 2 (CO2): Design heat exchanger network using pinch technology.

1. A problem table analysis for part of a high temperature process reveals that for ΔTmin = 20°C the process requires 9.2 MW of hot utility, 6.4 MW of cold utility and the pinch is located at 520 °C for hot streams and 500 °C for cold streams. The process stream data for the heat recovery network problem are given below. Design a MER HEN.

Stream No	Type	Supply temperature (◦C)	Target temperature (◦C)	Heat capacity flowrate ($MW \cdot K^{-1}$)
1	Hot	720	320	0.045
2	Hot	520	220	0.04
3	Cold	300	900	0.043
4	Cold	200	550	0.02

2. Write Euler's equation and briefly explain its use in process integration
3. How balanced composite curve differ from composite curve? Discuss on the application of these curves.

Course Outcome 3 (CO3): Modify processes for minimization of raw material and waste generation.

1. List out the heuristics for mass exchanger network design.
2. Design a network for the target water consumption system

Operation no	Contaminant mass (g/h)	C_{in} (ppm)	C_{out} (ppm)	Limiting water flow rate (t/h)
1	6,000	0	150	40
2	14,000	100	800	20
3	24,000	700	1000	80

3. Determine the minimum fresh water flow rate required for integration of the following operations

Operation number	Contaminant mass (g·h−1)	C_{in}(ppm)	C_{out} (ppm)	Limiting water flowrate (t·h−1)
1	2000	0	100	20
2	5000	50	100	100
3	30,000	50	800	40

Course Outcome 4 (CO4): Select suitable reactors for energy efficient operation.

1. How do you select an appropriate reactor for a given reaction under ideal conditions?
2. Discuss on different methods that can be adopted to control temperature in non-adiabatic reactions.
3. 'It is better to place the reactor above the pinch'. Comment on the statement.

Course Outcome 5 (CO5): Analyze energy optimal integration solutions for distillation columns.

1. Describe the use of grand composite curve for heat integration of distillation.
2. Vapor flow rate in kmol h^{-1} for each task for the separation of a four- component mixture are:

A/BCD 100 B/CD 90 ABC/D 240 A/B 70 A/BC 130 C/D 220
AB/CD 120 BC/D 250B/C 100 AB/C 140

3. Determine the best distillation sequence for minimum total vapour flow rate.
4. Describe different types of distillation sequencing used in simple distillation columns.

Model Question Paper

QP CODE: **PAGES: 4**

RegNo:______________

Name :______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SEVENTH SEMESTER B.TECH DEGREE EXAMINATION,

MONTH & YEAR

Course Code: CHT495

PROCESS INTEGRATION

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

(2019-Scheme)

PART A

(Answer all questions, each question carries 3 marks)

1. Define the term process integration.
2. Explain the applications of process integration.
3. Write Euler's equation and briefly explain its use in process integration
4. How balanced composite curve differ from composite curve? Discuss on the application **of** these curves.
5. List out the heuristics for mass exchanger network design.
6. What do you mean by limiting water flow rate?
7. 'It is better to place the reactor above the pinch'. Comment on the statement.
8. What do you mean by direct sequencing?
9. What is forward heat integration?
10. Select appropriate reactor for series reactions producing byproducts

PART B

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

Module I

11. A problem table analysis for part of a high temperature process reveals that for ΔTmin = 20°C the process requires 9.2 MW of hot utility, 6.4 MW of cold utility and the pinch is located at 520 °C for hot streams and 500 °C for cold streams. The process stream data for the heat recovery network problem are given below. Design a MER HEN.

Stream		Supply temperature (◦C)	Target temperature (◦C)	Heat capacity flow rate ($MW \cdot K^{-1}$)
No	Type			
1	Hot	720	320	0.045
2	Hot	520	220	0.04
3	Cold	300	900	0.043
4	Cold	200	550	0.02

12. For the given stream data prepare the grand composite curve for ΔTmin =10°C

Stream Number	Stream Type	Heat Capacity Flow Rate(kW/°C)	Source Temperature (°C)	Target Temperature (°C)	h, kW/m^2K
1	HOT-1	147.74	70	10	0.6
2	HOT-2	165.85	60	33	1
3	COLD-1	50	57	60	0.8
4	COLD-2	215	41	60	3
5	COLD-3	194.74	10	30	1

Module II

13. Calculate heat exchange network area for the given stream data

Stream		Supply temperature (◦C)	Target temperature (◦C)	Heat capacity flow rate ($MW \cdot K^{-1}$)
No	Type			
1	Hot	720	320	0.045
2	Hot	520	220	0.04
3	Cold	300	900	0.043
4	Cold	200	550	0.02

14. A problem table analysis for part of a high temperature process reveals that for ΔTmin = 20°C the process requires 9.2 MW of hot utility, 6.4 MW of cold utility and the pinch is located at

520 °Cfor hot streams and 500 °C for cold streams. The process stream data for the heat recovery network problem are given below. Design a MER HEN.

Stream		Supply	Target	Heat capacity flow
No	Type	temperature (◦C)	temperature (◦C)	rate ($MW \cdot K^{-1}$)
1	Hot	720	320	0.045
2	Hot	520	220	0.04
3	Cold	300	900	0.043
4	Cold	200	550	0.02

Module III

15. Using composite interval method determines minimum mass separating agent requirement for the streams given below.

Stream	Supply composition (mass fraction)	Target composition (mass fraction)	Mass flow rate ($kg \cdot s^{-1}$)	Solute transferred ($kg \cdot s^{-1}$)
Rich Stream 1	0.07	0.0005	0.9	0.06255
Rich Stream 2	0.051	0.0003	0.1	0.00507
Process MSA (y= 1.45x)	0.0008	0.031	2.3	0.06946
External MSA (y= 0.26x)	0.0001	0.0035	unlimited	unlimited

16. The following table presents water – use data for a simple example involving separations
    i. Target the minimum water consumption for the system through maximum water use
    ii. Design a network for the target water consumption

Operation no	Contaminant mass(g/h)	C_{in} (ppm)	C_{out} (ppm)	Limiting water flow rate (t/h)
1	6,000	0	150	40
2	14,000	100	800	20
3	24,000	700	1000	80

Module IV

17. How do you select an appropriate reactor for a given reaction under ideal conditions?
18. Discuss on heat integration characteristics of reactors.

Module V

19. With neat diagrams explain the following terms with reference to distillation
    a. Double effect distillation b. Direct sequence c. Indirect sequence d. Backward heat integration
20. A five component mixture is to be separated using sequences of distillation column. The data is

Component	A	B	C	D	E

Flow rate (kmol/h)	269	282	57	215	42
Relative volatility	6.24	3.28	1.86	1.76	1

The designer wishes to do A/BCDE first, propose the best distillation sequence using 'ROTE' method.

Syllabus

Module 1 **(10 Hrs.)**

Process Integration: Definition of Process Integration, Areas of application and techniques available for Process Integration, Onion model of chemical process design, Role of thermodynamic laws.

Energy targeting methods of Heat Exchanger Networks: Composite curve method, Problem table algorithm, Grand composite curve.

Module 2 **(8 Hrs.)**

Targeting of Heat Exchanger Network: Number of units targeting, Area targeting, Cost targeting, Number of shells targeting.

Heat Exchanger Network Design: The pinch design method, Grid diagram, Stream splitting design for single pinch networks.

Module 3 **(10 Hrs.)**

Mass Exchanger Network Synthesis: Mass Exchanger Network, Minimum Mass Separating Agents (MSA), Mass exchange networks for minimum external MSA.

Water system design: Water use, Targeting maximum water reuse for single contaminants.

Module 4 **(8 Hrs.)**

Integration of Reactor systems: Choice of Idealized reactor model and reactor performance. Reactor configurations: Temperature Control, Choice of Reactors. Heat Integration characteristics of reactors, appropriate placement of reactors.

Module 5 **(9 Hrs.)**

Integration of Distillation systems: Distillation sequencing, Heat Integration characteristics of a Distillation column, appropriate placement of distillation column.

Text Books

1. Robin Smith, Chemical Process Design and Integration, John Wiley and Sons. Ltd., New Delhi, 2005.
2. Uday. V. Shenoy, Heat Exchanger Network Synthesis, Gulf Publishing Co, USA, 1995

Reference Books

1. Warren D. Seider, J. D. Seader and Daniel R. Lewin, Product & Process Design Principles, Wiley Publication.
2. James M. Douglas, Conceptual Design of Chemical Process, McGraw Hill, New York, 1988.
3. Kemp I.C, Pinch Analysis and Process Integration - A user guide on process integration for efficient use of energy, 2nd Edition, Butterworth – Heinneman, 2006.
4. Linnhoff, B. Townsend D.W., Boland D., Hewitt G.F., Thomas, B.E.A., Guy, A. R. and Marsland, R. H., "A User's guide on process integration for the efficient use of energy", Inst. of Chemical Engineers, London (1982).
5. Mahmoud. M., El – Hawalgi, Process Integration -, Elsevier, 2006.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Module I**	**10**
1.1	Process Integration: Definition of Process Integration, Areas of application and techniques available for Process Integration.	1
1.2	Onion model of chemical process design, Role of thermodynamic laws.	1
1.3	Energy targeting methods of Heat Exchanger Networks: Hot Composite curve	2
1.4	Cold composite curve	1
1.5	Pinch determination	2
1.6	Problem table algorithm	2
1.7	Grand composite curve	1
2	**Module II**	**8**
2.1	Targeting of Heat Exchanger Network: Area targeting	3
2.2	Number of units targeting, Cost targeting, Number of shells targeting.	2
2.3	Heat Exchanger Network Design: The pinch design method	1
2.4	Grid diagram, Stream splitting design for single pinch networks.	2
3	**Module III**	**10**
3.1	Mass Exchanger Network Synthesis: Mass Exchanger Network	1
3.2	Minimum Mass Separating Agents (MSA): Concentration interval method	2
3.3	Composite curve method	2
3.4	Mass exchange networks for minimum external MSA	2
3.5	Water system design: Water use	1
3.6	Targeting maximum water reuse for single contaminants.	2
4	**Module IV**	**8**
4.1	Integration of Reactor systems: Choice of Idealized reactor model and reactor performance.	2

4.2	Reactor configurations: Temperature Control	2
4.3	Choice of Reactors.	2
4.4	Heat Integration characteristics of reactors	1
4.5	Appropriate placement of reactors.	1
5	**Module V**	**9**
5.1	Integration of Distillation systems: Distillation sequencing	3
5.2	Heat Integration characteristics of Distillation column	3
5.3	Appropriate placement of distillation column.	3

CHT497	PROCESS DESIGN FOR WASTEWATER TREATMENT	CATEGORY	L	T	P	CREDIT
		VAC	3	1	0	4

Preamble: This course focuses on the application of theory and the design of physical, chemical and biological unit operations for the treatment of wastewater. It covers characteristics of wastewater; primary, secondary & tertiary treatment processes; sludge disposal and treatment; and design of water and wastewater treatment systems. At the end of the course, the students will have a working knowledge of the wastewater industry and have the skills to perform a preliminary design of a treatment plant.

Prerequisite: Basic course on wastewater engineering is required (desirable)

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

CO 1	Understand the basic characteristics of wastewater, understand the main design criteria and operational parameters for wastewater treatment processes, and apply the knowledge in the process design.
CO 2	Develop the reaction rate kinetics for biological treatment.
CO 3	Describe the main design criteria and operational parameters for aerobic biological treatment processes, and apply the knowledge in the process design.
CO 4	Explain the mechanism of anaerobic treatment and understand the design and working principle of anaerobic treatment system.
CO 5	Understand the principles of excess sludge treatment and apply the knowledge in the process design.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3		3									3
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
	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. Give a detailed account of characteristics of screening.
2. How are the characteristics of waste water expressed?
3. Explain in detail about the characteristics of waste water.

Course Outcome 2 (CO2):

1. With the help of figure explain how the rate of metabolism and hence the growth phase will vary with changes in food to microorganisms ratio in case of continuously feed biological reactor.
2. Explain nutritional requirements for bacterial metabolism.
3. Describe the types of microbial metabolism used in wastewater treatment.

Course Outcome 3(CO3):

1. Discuss operational problems in activated sludge process and suggest their remedies
2. List three possible process changes in an activated sludge process. Briefly explain the purpose of each change.
3. An activated sludge plant is designed to reduce 90% of influent BOD of 250 mg/L. Compute (a) net sludge (solids) produced per day, (b) mean cell residence time, (hydraulic retention time), and (d) the F/M ratio for the assumed design data given below.
   1) Wastewater flow = 2 MLD
   2) Volume of the aeration tank = 500 m^3
   3) MLVSS in the aeration tank = 2500 mg/L
   4) Kinetic coefficients, Y = 0.5 and kd = 0.08 d^{-1}

Course Outcome 4 (CO4):

1. Explain the different types of anaerobic treatment processes. Anaerobic treatment is not generally accepted for wastewater treatment. Why?
2. Explain with neat sketches the different types of digesters used for anaerobic sludge digestion.
3. Describe the major factors that are considered in the design of reactors for anaerobic biological treatment processes.

Course Outcome 5 (CO5):

1. Distinguish between high rate digestion and low rate digestion.
2. Write a note on ultimate sludge disposal with suitable examples.
3. Explain with neat sketches the different types of digesters used for anaerobic sludge Digestion

Model Question Paper

QP CODE: **PAGES: 4**

Reg No:______________

Name :______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SEVENTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: CHT497

PROCESS DESIGN FOR WASTEWATER TREATMENT

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

(2019-Scheme)

PART A

(Answer all questions, each question carries 3 marks)

1. What are the different screens used for water treatment.
2. Mention the different grid chamber configurations with their specification
3. What is meant by F/M ratio? State the significance.
4. Define (i) Yield coefficient (ii) Specific substrate utilization rate (iii)Decay coefficient.
5. Explain why microbiology is important in the activated sludge process
6. Define sludge volume index (SVI) and explain its significance in the design of aerobic biological wastewater treatment?
7. Why aerobic processes produce more sludge as compared to anaerobic process?
8. What is the major difference between suspended growth and attached growth processes?
9. Mention the different types of pumps used for handling sludge with their application.
10. What is centrifugal thickening? When is it used?

PART B

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

Module I

11. Draw and explain a standard flow chart for waste water treatment process

OR

12. Explain in detail about the different types of reactors used in sewage treatment plants with their characteristics.

Module II

13. Explain in detail about the types of biological process for waste water treatment.

OR

14. Give a detailed account of microbial growth phases. What are the factors effecting microbial growth.

Module III

15. What is meant by aeration? Explain in detail about the various methods of aeration.

OR

16. Distinguish between the various kinds of activated sludge processes. Explain the significant design criteria and steps for designing a conventional activated sludge process.

Module IV

17. With the help of schematic diagram explain the carbon flow conversion in anaerobic digesters

OR

18. With a neat sketch, explain the working of an up-flow anaerobic sludge blanket reactor (UASBR). What are its main advantages and disadvantages?

Module V

19. Explain the principle working and construction of rotary press for dewatering of sludge. Mention its advantages and disadvantages.

OR

20. Explain the design of sludge management facilities

****

Syllabus

Module 1 **(10 Hrs.)**

Objectives of wastewater treatment, characteristics, flow variations, types of reactors and reactors analysis. Wastewater Treatment Flow Diagrams, Theoretical principles and design considerations - screens, equalization basin, grit chamber, primary and secondary settling tanks.

Module 2 **(8 Hrs.)**

Objectives of biological treatment – Role of microorganisms in wastewater treatment, types of biological processes for wastewater treatment, suspended and attached growth systems. Microbiological treatment kinetics and flow regimes – Michaelis-Menten and Monod models – Rate of biomass growth with soluble substrates – Kinetic coefficients – Effect of temperature – Oxygen requirements – Biomass yield – Observed yield – Kinetic constants evaluation of biological treatment

Module 3 **(10 Hrs.)**

Aerobic biological treatment – Attached growth and suspended growth treatment systems – Modeling suspended growth treatment process – Activated sludge process – Description – Various types – Methods of aeration – Microbiology – Process analysis – Process design

considerations – Operational difficulties – Modifications.

Module 4 **(8 Hrs.)**

Mechanism of anaerobic treatment, factors affecting anaerobic treatment -General design considerations for anaerobic treatment system – Anaerobic suspended process- Design of anaerobic suspended growth process– Design considerations for up-flow anaerobic sludge blanket process – Methods to enhance solid loading & digester performance – Gas production, collection and use.

Module 5 **(9 Hrs.)**

Design of Sludge management facilities, Characteristics of sludge, Sludge Processing, Preliminary operations, Thickening, Stabilization, Aerobic digestion, Anaerobic digestion, sludge dewatering (mechanical and gravity) - ultimate residue disposal - Recent Advances.

Text Books

1. Metcalf & Eddy, Inc. Wastewater Engineering, Treatment and Reuse. 5th Edition, Tata McGraw-Hill, New Delhi, 2010
2. Mark J. Hammer and Mark J Hammer Jr., Fourth Edition, Water and Wastewater Technology, Prentice Hall of India Pvt. Ltd.
3. "Wastewater Treatment Concepts and Design Approach", Karia G.L., and

Christian R.A., (2001), Prentice Hall of India Pvt. Ltd., New Delhi.

Reference Books

1. Benefield, L.D. and Randall C.W. Biological Processes Design for wastewaters, Prentice-Hall, Inc. Eaglewood Cliffs, 1982.
2. Environmental Engineering – A design approach by Arcadio P. Sincero & Grecjoria A. Sincero (Prentice Hall of India).
3. Grady Jr. C.P.L and Lin H.C. Biological wastewater treatment: Theory and Applications, Marcel Dekker, Inc New York, 1980.
4. Qasim, S.R, "Wastewater Treatment Plant, Planning, Design & Operation", Technomic Publications, New York, 2004.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Module 1**	**10**
1.1	Objectives of wastewater treatment	1
1.2	Characteristics, flow variations,	1
1.3	Types of reactors	1
1.4	Reactors analysis.	2
1.5	Wastewater Treatment Flow Diagrams,	1
1.6	Theoretical principles and design considerations - screens,	1
1.7	Theoretical principles and design considerations - equalization basin, grit chamber	1
1.8	Theoretical principles and design considerations - primary and secondary settling tanks.	2
2	**Module 2**	**8**
2.1	Objectives of biological treatment – Role of microorganisms in waste water treatment	1
2.2	types of biological processes for wastewater treatment,	1
2.3	suspended and attached growth systems.	1
2.4	Microbiological treatment kinetics and flow regimes	1
2.5	Michaelis-Menten and Monod models	1
2.6	Rate of biomass growth with soluble substrates – Kinetic coefficients	1
2.7	Effect of temperature – Oxygen requirements – Biomass yield –	1

	Observed yield	
2.8	Kinetic constants evaluation of biological treatment	1
3	**Module 3**	**10**
3.1	Aerobic biological treatment	1
3.2	Attached growth and suspended growth treatment systems	2
3.3	Modeling suspended growth treatment process	2
3.4	Activated sludge process – Description – Various types – Methods of aeration, Microbiology	2
3.5	Process analysis – Process design considerations	2
3.6	Operational difficulties – Modifications	1
4	**Module 4**	**8**
4.1	Mechanism of anaerobic treatment, factors affecting anaerobic treatment	1
4.2	General design considerations for anaerobic treatment system	1
4.3	Anaerobic suspended process- Design of anaerobic suspended growth process	2
4.4	Design considerations for upflow anaerobic sludge blanket process	2
4.5	Methods to enhance solid loading & digester performance – Gas production, collection and use.	2
5	**Module 5**	**9**
5.1	Design of Sludge management facilities,	1
5.2	Characteristics of sludge, Sludge processing	1
5.3	Preliminary operations, Thickening, Stabilization	2
5.4	Aerobic digestion, Anaerobic digestion,	2
5.5	Sludge dewatering (mechanical and gravity)	2
5.6	Ultimate residue disposal - Recent Advances	1

CHT499	ADVANCED PROCESS CONTROL	CATEGORY	L	T	P	CREDIT
		VAC	3	1	0	4

Preamble: Process control techniques allow manufacturers to keep their operations running within specified limits and to set more precise limits to maximize profitability, ensure quality and prioritize safety. 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.
This course would enable students to gain knowledge on stability analysis using frequency response, transient response of closed and open-loop 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 equipment and processes.

Prerequisite: CHT307 Instrumentation and Process Control

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

CO 1	Describe the various representations of control systems and analyse servo and regulatory problems of closed loop systems
CO 2	Analyse the stability of linear systems using analytical and graphical methods and evaluate controller tuning parameters
CO 3	Apply modern control strategies suitable for specific control applications
CO 4	Determine the dynamics of industrial equipments and choose control valves for a particular application
CO 5	Summarize the concepts of digital process control

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		2	2					
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.

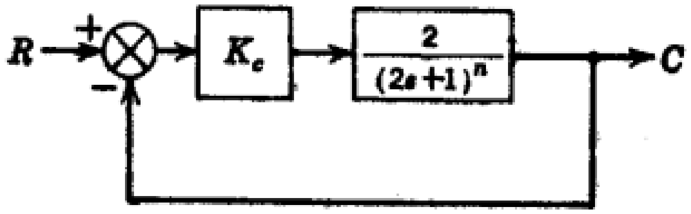
Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Consider a process $G_p = 0.2/(-s+1)$, that is open loop unstable. If $G_v = G_m = 1$, determine whether a proportional controller can stabilize the system.
2. Write short note on the error performance indices method for controller efficiency.

Course Outcome 2 (CO2)

1. Using Nyquist stability criterion, investigate the closed-loop stability of a system whose open-loop transfer function is given by $G(s)H(s) = \frac{(s+2)}{(s+1)(s-1)}$
2. Calculate the value of gain K_c needed to produce continuous oscillations in the control system shown below, when a) n is 2 and b) n is 3 without using graph.



Course Outcome 3 (CO3):

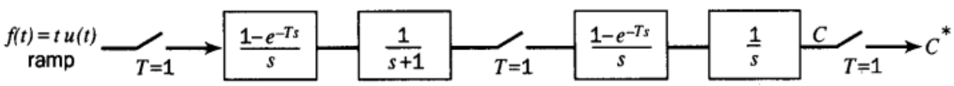
1. Explain the main features of Smith predictor controller with an example.
2. In a fluidized bed combustor the fuel to air percentage is to be strictly maintained as 75%, write the main features of the advanced controller suitable for this purpose.

Course Outcome 4 (CO4):

1. Describe the equal percentage valve giving emphasis to characteristics and sizing ranges. What are the benefits of equal percentage valve?
2. Derive the transfer function for two-plate gas absorber stating clearly the assumptions involved.

Course Outcome 5 (CO5):

1. For the sample data process in figure determine (a) C(z) and b c(nT) for several values of n.



2. Write the BIBO stability criterion in s plane and deduce the stability region in z plane.

Model Question Paper

QP CODE: **PAGES:3**

Reg No:______________

Name :______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
SEVENTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR
Course Code: CHT499
Advanced Process Control

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

(2019-Scheme)

PART A

(Answer all questions, each question carries 3 marks)

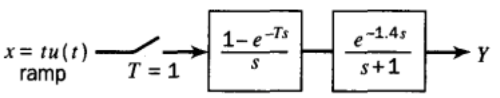
1. A unit step change in error is introduced in to a PID controller. If $K_c = 10$, $\tau_I = 1$ and $\tau_D = 0.5$, plot the response of the controller.
2. A step change of magnitude 4 is introduced into a system having the transfer function

   $$\frac{Y(s)}{X(s)} = \frac{10}{s^2 + 1.6s + 4}$$

   Determine i) Percent overshoot ii) Rise time iii) Maximum value of Y(t)
3. Determine the stability of the characteristic equation by Routh test.

   $$2s^4 + s^3 + 3s^2 + 4s + 10 = 0$$
4. Explain the Cohen and Coon method of finding controller parameters.
5. Describe the concept of Model Predictive Control.
6. Explain the salient features of SCADA.
7. A multi-capacity system transfer function is given by $G(s) = \frac{e^{-0.5\,s}}{(10s+1)(6s+1)(2\,s+1)}$

   Write the approximate FOPTD model using Skogestad's half rule.
8. Differentiate lumped parameter analysis and distributed parameter analysis each with the help of an example.
9. For the process shown in figure, determine Y(z). By the method of long division, find Y(nT) for n = 0,1,2 and 3.



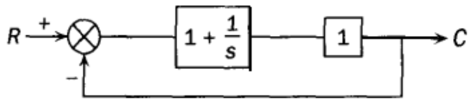
10. Derive the digital form of PID controller from the analog form.

PART B

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

Module I

11. a) For a control system shown in figure, determine the expression for C(t) if a unit step change occurs in R. Sketch the response C(t) and compute C(2).

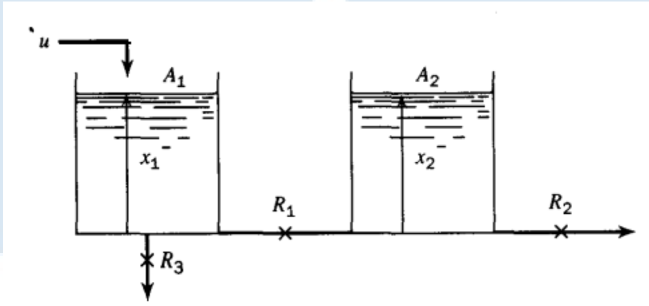


(8 marks)

b) Derive the input-output model and state the degrees of freedom in a stirred tank heater.

(6 marks)

12. For a system shown in figure, find A and b in **x˙ = Ax + bu**. The tanks are interacting. The following data apply: A_1= 1, A_2= ½, R_1= ½, R_2= 2, R_3=1



(14 marks)

Module II

13. A transfer function of a process and a measurement element connected in is given by

$$\frac{e^{-0.4s}}{(2s+1)^2}$$

a) Sketch the open-loop Bode diagram (gain and phase) for this system. (5 marks)

b) Write short note on Zeigler-Ncholas controller settings. (4 marks)

c) Specify the parameters of PID controller to be used in the control system with above transfer function by Z-N settings. (5 marks)

14. A unity feedback system has open-loop transfer function

$$G(s) = \frac{K}{s(2s-1)}$$

Draw the Nyquist diagram and investigate the stability of the system.

(14 marks)

Module III

15. A process has transfer function $G(s) = \frac{2e^{-0.5s}}{(10s+1)(5s+1)(S+1)}$. With the help of required sketches explain the implementation of Smith predictor control for this process. Explain the working of the control system. (14 marks)

16. Write short notes on a) cascade control, b) inferential control c) adaptive control d) model predictive control. (14 marks)

Module IV

17. a) Derive the transfer function for double pipe heat exchanges using partial differential equation. (10 marks)

b) Construct a linear control valve showing clearly valve positioner. (4 marks)

18) a) Explain the procedure to obtain a first order plus time delay model from process reaction curve. (4 marks)

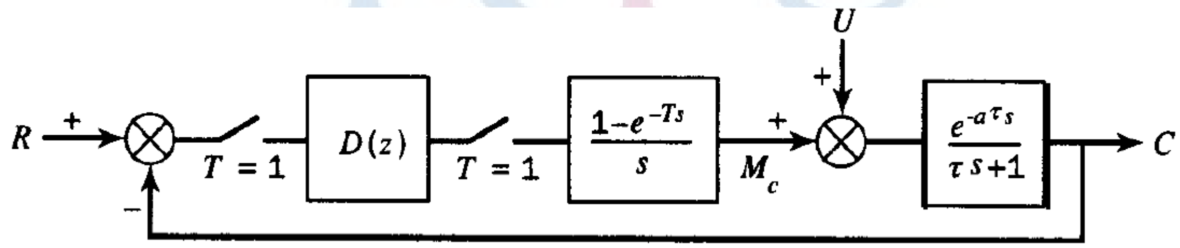
b) Derive, explain and sketch the commonly used control valve characteristics. (10 marks)

Module V

19. The sample data system shown on figure uses the following control algorithm

$D(z) = \frac{z(z-b)}{(1-b)(z+1)(z-1)}$

Where $b = e^{-T/\tau} = e^{-1}$. For a process $\tau = 1$, a=1, $T = a\tau = 1$, if a unit step enters as a load change, determine C(z). Plot continuous response c(t). Determine values of c(nT) at n = 1, 2, 3 and 4.



(14 marks)

20. a) Derive pulse transfer function for a first order process G(s) = A/(2s+1) with a zero order hold. Determine the offset for servo problem when a step change of 5 in set point is introduced to the feedback control system with proportional controller K_c = 0.5.

(14 marks)

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Syllabus

Module 1 **(10 Hrs.)**

Open loop and closed loop systems: Importance of modelling for process control - the input-output model, degrees of freedom, input-output model and degrees of freedom in a stirred tank heater.
Open loop and closed loop response of LTI systems - Characteristics of second order underdamped step response, Different modes of controllers - P, PI and PID, closed loop response of first and second order systems, Performance criteria of controllers — the error performance indices.
Introduction to multivariable control systems, interaction in MIMO systems.
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.

Module 2 **(8 Hrs.)**

Stability Analysis: Routh Hurwitz criteria, Bode diagrams, Bode stability criterion, gain margin and phase margin, Nyquist plots – stability analysis using Nyquist stability criteria, Controller tuning - Ziegler-Nichols settings, Cohen-Coon tuning methods, Relay tuning.

Module 3 **(8 Hrs.)**

Advanced Control Strategies: cascade control, ratio control, feed forward control, adaptive control, selective control, inferential control, Smith predictor. Introduction to Model predictive control, PLC and SCADA.

Module 4 **(9 Hrs.)**

Process applications: Control valves — characteristics, sizing and valve positioners.
Process identification using Process reaction curve- semi log plot method, First order plus time delay models, Approximation of multi-capacity systems to FOPTD by Skogestad's half rule.
Theoretical analysis of complex processes - Dynamics of two plate gas absorber and double pipe heat exchanger.

Module 5 **(10 Hrs.)**

Sample Data Control systems: Sampling continuous signals, ADC and DAC, Reconstruction of continuous signals from discrete time values, Zero order and first order holds, Basic review of Z transforms, Properties of Z-transforms, inversion of Z-transforms, Response of discrete systems to various inputs - Open loop response to step and impulse inputs, Discrete time analysis of continuous time systems – The Pulse transfer function, Transient response of closed-loop sampled data systems- servo and regulatory problems, mapping, Stability analysis of discrete time systems – stability regions in S and Z planes, Digital approximations of PI and PID controllers.

Text Books

1. Coughanowr D.R, Stevan E. LeBlanc Process Systems Analysis & Control, Third Edition, McGraw Hill.
2. Stephanopoulos G., Chemical Process Control, An Introduction to Theory & Practice, Prentice Hall of India.
3. Dale E. Seborg, Thomas F. Edgar and Duncan A. Mellichamp, Process Dynamics and Control, John Wiley& Sons Inc. Second Edition.
4. Katsuhiko Ogata, State space analysis of control systems, Prentice – Hall
5. Kuo,B.C, Analysis and synthesis of sampled data control systems, Prentice –Hall.

Reference Books

1. C.A. Smith and A.B. Corripio. 'Principle and Practice of Automatic Process Control', 3rd Edition., John Wiley and Sons, 2005.
2. W.L. Luyben, Process modeling, Simulation and Control for Chemical Engineers, McGraw Hill.
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 1**	**9**
1.1	Open loop and closed loop systems: Importance of modelling for process control, Input-output model, degrees of freedom,	1
1.2	Input-output model and degrees of freedom in a stirred tank heater	1
1.3	Characteristics of second order underdamped step response	1
1.4	Different modes of controllers - P, PI and PID, closed loop response of first and second order systems, offset, integral wind up, derivative kick	2
1.5	Performance criteria of controllers — the error performance indices	1
1.6	Introduction to multivariable control systems, interaction in MIMO systems	1
1.7	Introduction to state space analysis, Definitions of state space, State variables and equilibrium points	1
1.8	Representations of systems described by differential equations and transfer functions in state variable form	1
2	**Module 2**	**8**
2.1	Stability Analysis: Routh Hurwitz criteria	1
2.2	Bode diagrams	1
2.3	Bode stability criterion, gain margin and phase margin	1
2.4	Nyquist plots	1
2.5	Stability analysis using Nyquist stability criteria	1
2.6	Controller tuning - Ziegler-Nichols settings	2
2.7	Cohen-Coon tuning methods, Relay tuning	1
3	**Module 3**	**8**
3.1	Advanced Control Strategies-Introduction	1
3.2	Cascade control	2
3.3	feed forward control, , ratio control	2
3.4	Smith predictor	1
3.5	Inferential control, Adaptive control, selective control	1
3.6	Introduction to Model predictive control, DCS, PLC, SCADA	1
4	**Module 4**	**10**
4.1	Process applications: Control valves — characteristics, sizing and valve positioners.	3
4.2	Process identification using Process reaction curve	1
4.3	First order plus time delay models (FOPTD), Skogestad's half rule	1
4.4	Theoretical analysis of complex processes - Dynamics of two plate gas absorber	3
4.5	Dynamics of double pipe heat exchanger	2
5	**Module 5**	**10**
5.1	Sample Data Control systems: Discrete time control loops, ADC and DAC, Sampling and signal reconstruction, Zero order and first order	2

	hold elements aliasing, guidelines for selecting sampling period.	
5.2	Basic review of Z transforms, Properties of z-transforms, inversion of z-transforms, difference equation to z-transform conversion	2
5.3	Discrete time analysis of continuous time systems -The Pulse transfer function, Open loop response to various inputs - step and impulse inputs	2
5.4	Transient response of closed-loop sampled data systems- servo and regulatory problems,	2
5.5	Stability of discrete time systems – mapping from s to z domain, stability regions in s and z planes	1
5.6	Digital approximations of PI and PID controllers.	1

SEMESTER VIII

CHT402	CHEMICAL PROCESS EQUIPMENT DESIGN II	CATEGORY	L	T	P	CREDIT
		PCC	2	1	0	3

Preamble: This course is continuation of the course 'Chemical Process Equipment Design I' studied in seventh semester. The objective of this course is to give a foundation for the undergraduates in the design of equipments used in process industries for the unit operations such as distillation, gas absorption, liquid extraction and drying. This course includes sizing of equipment, selection of material of construction and mechanical design.

Prerequisite: Knowledge in heat and mass transfer, process calculations, fluid and particle mechanics, thermodynamics, material science and engineering mechanics

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

CO 1	Design binary tray distillation column
CO 2	Design packed bed absorption column
CO 3	Design sieve tray extraction column
CO 4	Design direct heat rotary dryer
CO 5	Design thin-walled unfired pressure vessels using Indian Standard codes

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

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember			
Understand			
Apply	50	50	100
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:

- Question paper contains 2 numerical design questions from each module of which the student shall have to answer any one from each module. Each question carries 50 marks. There can be subdivisions for the main question/topic only.
  The questions should be clear in respect of type of equipment and its alignment if any, operating conditions, and materials handled. Data required for design such as equilibrium data and physical properties - in case it cannot be obtained from handbook, type of equipment, material of construction and terrestrial data for mechanical design etc. shall be provided with the question.
- Question paper should contain instruction as given below:
  Apart from scientific calculators (including programmable) the following books and data books are permitted for the exam:
  1. Steam tables
  2. IS Codes
  3. Perry's Handbook
  4. Nomographs, charts and tables used in design taken from IS codes/ Other editions of Handbook as directed by university
  5. Attested copy of Sieve tray hydraulics and sieve tray mass transfer for liquid extraction from 'Mass Transfer Operations' by Robert E. Treybal , pg 532-538

Course Level Assessment Questions

Course Outcome 1 (CO1): *Design binary tray distillation columns*

1. A continuous distillation column produces 24,000 kg/hr of aqueous acetic acid with a concentration of 97% by weight from a feed mixture of acetic acid and water containing 60% by weight acid. The feed and reflux are at their bubble points. The distillate contains 98% by weight water. The pressure in the column is atmospheric and the reflux ratio is 1.5 times the minimum required.

   VLE data at 1atm:

Temperature, ^oC	118.3	110.6	107.8	105.2	104.3	103.5	102.8

Mole fraction of water	Liquid	0.0	0.188	0.308	0.450	0.520	0.582	0.675
	Vapor	0.0	0.306	0.447	0.597	0.658	0.711	0.780
Temperature, ^oC		102.1	101.5	100.8	100.8	100.5	100.2	100
Mole fraction of water	Liquid	0.726	0.795	0.856	0.879	0.913	0.958	1.0
	Vapor	0.824	0.867	0.904	0.919	0.941	0.971	1.0

Course Outcome 2 (CO2) *Design packed bed absorption column*

2. 10,000 kg/h of SO_2 bearing air is to be cleaned using water at 30^{o}C in a counter current absorption tower. The concentrations of SO_2 in the inlet air entering the absorber is 12% by weight and the air leaving the absorber is 1% by weight.
   a) Design absorption
   b) Design a suitable packed column using 25mm Raschig rings

Course Outcome 3(CO3): *Design sieve tray extraction column*

3. A feed of one thousand kilograms aqueous solution of pyridine per hour (50% by mass) is to be extracted with pure benzene to reduce the solute content in the raffinate to 2%. Design the sieve tray column for the liquid-liquid extraction operating at 1 atm and 30^{o}C. Assume benzene and water are completely immiscible
   Distribution coefficient = 0.562
   Interfacial tension = 2x 10^{-5} N/m
   Density of aqueous phase = 1000 kg/m^3
   Density of organic phase =850 kg/m^3

Course Outcome 4 (CO4): *Design direct heat rotary dryer*

4. A counter current direct heat rotary dryer is used for drying 0.82 kg/s wet ore obtained from a froth floatation with 15% moisture using hot air available at 250^{o}C and humidity 0.012. The solid inlet temperature is 32^{o}C and is to be discharged at 90^{o}C.
   Properties of ore:
   Bulk density = 1800 kg/m^3 of dry solid
   Mean specific heat = 2400 J/kg^{o}C
   Particle size = 200 micron
   a. Calculate the air rate required
   b. Estimate the drying temperature of solids.
   c. Estimate dryer diameter and length
   d. Evaluate percentage hold up if slope is 1 in 50.

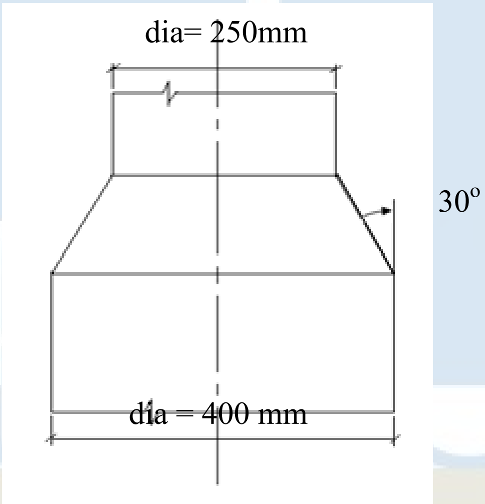
Course outcome 5 (CO5): *Design thin-walled unfired pressure vessels using Indian Standard codes*

5. A vertical cylindrical vessel having nominal diameter 1.2 m and tangent to tangent length 2.4 m with torri-spherical top end and conical bottom (apex angle 120^o) is to be installed in a plant. The

vessel is used for hydrocarbon processing and has to be fabricated with IS: 2002- 1962 Gr.2B steel. The vessel is to be designed for a maximum internal operating pressure of 6 MN/ m^2 at 350 ^oC. The vessel is erected by means of bracket supports and the supports are located at one third of shell height measured from the bottom. Perform the mechanical design of the vessel by neglecting the dynamic loads and draw the sectional elevation.

6. a) A horizontal cylindrical pressure vessel having nominal diameter 2.0 m and tangent to tangent length 3.75 m is to be installed in a plant. The vessel is used for a corrosive fluid and has to be fabricated with IS: 2002- 1962 Gr.2B steel. The vessel is to be designed for a maximum internal operating pressure of 10 kg/ cm^2 at 300^oC. Perform the mechanical design of the vessel by neglecting the dynamic loads, if hemi-spherical ends are employed.

   b) Design the conical transition section of a pressure vessel as shown in the figure1. Check the cone-shell junction. Allowable stress for the material is 13.8 kgf/mm^2. Welded joint efficiency is 85%. The design pressure is 10 kgf/cm^2



Model Question Paper

QP CODE: PAGES: 2

Reg No: ________________

Name: _________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

EIGHTH SEMESTER B. TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: CHT402

Max Duration: 3 Hours Marks:100

CHEMICAL PROCESS EQUIPMENT DESIGN II

(2019 Scheme)

Instructions:

Apart from scientific calculators (including programmable) the following books and data books are permitted for the exam:

1. *Steam tables*
2. *IS Codes*
3. *Perry's Handbook*
4. *Copies of nomographs, charts and tables used in design taken from IS codes/ / Other editions of Handbook duly attested by the course faculty*
5. *Attested copy of Sieve tray hydraulics and sieve tray mass transfer for liquid extraction from 'Mass Transfer Operations' by Robert E. Treybal , pg 532-538*

(Answer any **one** full question from each module. Each full question carries 50 marks)

Module -I

1. A continuous distillation column produces 24,000 kg/hr of aqueous acetic acid with a concentration of 97% by weight from a feed mixture of acetic acid and water containing 60% by weight acid. The feed and reflux are at their bubble points. The distillate contains 98% by weight water. The pressure in the column is atmospheric and the reflux ratio is 1.5 times the minimum required.

VLE data at 1atm:

Temperature, ^{o}C		118.3	110.6	107.8	105.2	104.3	103.5	102.8
Mole fraction of water	Liquid	0.0	0.188	0.308	0.450	0.520	0.582	0.675
	Vapor	0.0	0.306	0.447	0.597	0.658	0.711	0.780
Temperature, ^{o}C		102.1	101.5	100.8	100.8	100.5	100.2	100
Mole fraction of water	Liquid	0.726	0.795	0.856	0.879	0.913	0.958	1.0
	Vapor	0.824	0.867	0.904	0.919	0.941	0.971	1.0

a) For a sieve tray column, calculate the number of actual trays in each section and location of feed stage for an overall tray efficiency of 64%. (15 marks)

b) Design a segmented sieve tray column and estimate pressure drop (35marks)

OR

2. 10,000 kg/h of SO_2 bearing air is to be cleaned using water at 30°C in a counter current absorption tower. The concentration of SO_2 in the inlet air entering the absorber is 12% by weight and the air leaving the absorber is 1% by weight.
   a) Design absorption (15 marks)
   b) Design a suitable packed column (35 marks)

Module -II

3. A counter current direct heat rotary dryer is used for drying wet ore obtained from a froth floatation with 15% moisture using hot air available at 250°C and humidity 0.012. The solid inlet temperature is 32°C and is to be discharged at 90°C. Calculate the air rate required to achieve N_{TOG} of 2 and estimate the drying temperature of solids.

(50 marks)

OR

4. A tall vertical packed column is 3.6 m diameter and 28m height. The design pressure and temperatures are 15 kg/cm^2 and 250 °C. The vessel is required for a location where wind velocity expected is 150 kmph and seismic coefficient is 0.07. The loading of liquid and packing is 1700 kg/m^3 of vessel volume. Semi-ellipsoidal ends with major to minor axis ratio of 2:1 are used. The height of the top, middle and bottom chambers are 2m each. Weight of platforms, ladder and overhead pipelines is 160 kg/m. Weight of packing supports and liquid distributors (two each) = 400 kg each. Determine the thickness of the shell at various heights of the column. *(50 marks)*

Syllabus

Module 1

Process design of steady state isothermal binary component tray distillation columns (Sieve and valve tray): Estimation of theoretical number of stages using McCabe Thiele method –Tray design – tray efficiency - pressure drop, entrainment, downflow flooding and weeping.

Process design of steady state isothermal packed bed absorption and stripping column for dilute systems without chemical reaction: Number of transfer units- height of transfer units – column diameter – packing height-liquid distribution-pressure drop

Process design of single solvent sieve tray extraction columns for immiscible system: Number of trays, sieve tray design, height of coalesced layer, Murphree efficiency

Module 2

Design of Direct heat Rotary Dryers: Estimation of air quantity, drying temperature, Number of Transfer Units, Diameter of dryer, Length, speed, slope, flight, hold up time

Mechanical design of process equipment: Design of thin-walled pressure vessels as per IS 2825 – Shells subject to internal and external pressure- estimation of minimum thickness- corrosion allowance - standard plate thickness – flat ends, ends concave to pressure and convex to pressure: dished and flanged ends, conical ends Mechanical design of tall pressure vessels : design of thin walled multi-course pressure vessels as per IS 2825 – Estimation of thickness of shells subject to external loads (wind and seismic)

Reference Books, codes and standards

1. Perry. R.H & Green.D.W., *Chemical Engineers Handbook*, Mc- Graw Hill.
2. Robert E. Treybal, *Mass Transfer Operations*
3. Kern D.Q., *Process Heat Transfer*, Tata McGraw Hill.
4. Badger & Bancharo, *Introduction to Chemical Engineering*, McGraw Hill
5. Coulson J.M.& Richardson J.F., *Chemical Engineering*, Vol.6, 3rd Edn, Butterworth-Heinemann, (Indian print)
6. M.V Joshi & Mahajan V.V., *Process Equipment Design*, 3rd Edn, Mac-Milan & Co. India.
7. McCabe W.L., Smith J.C. & Harriott P., *Unit Operations in Chemical Engineering*, McGraw Hill.
8. B.C Bhattacharya, *Introduction to Chemical Equipment Design*, CBS Publishers & Distributors, New Delhi.
9. E. Ludwig, *Applied Process Design for Chemical & Petrochemical Plants*, Vol I, II, III, Gulf Publication, London.
10. IS Codes: Bureau of Indian Standards

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Module 1**	**18**
1.1	Process design of steady state isothermal binary component tray distillation columns (Sieve and valve tray): Estimation of theoretical number of stages using McCabe Thiele method –Tray design –tray efficiency - pressure drop, entrainment, downflow flooding and weeping.	7
1.2	Process design of steady state isothermal packed bed absorption and stripping column for dilute systems without chemical reaction: Number of transfer units- height of transfer units – column diameter – packing height- liquid distribution-pressure drop	6
1.3	Process design of sieve tray single solvent extraction columns for immiscible system : Number of trays, sieve tray design, height of coalesced layer, Murphree efficiency	5
2	**Module 2**	**17**
2.1	Design of Direct heat Rotary Dryers: Estimation of air quantity, drying temperature, Number of Transfer Units	4
2.2	Diameter of dryer, Length, speed, slope, flight, hold up time	2
2.3	Mechanical design of process equipment: Design of thin-walled pressure vessels as per IS 2825 – Shells subject to internal and external pressure-estimation of minimum thickness- corrosion allowance - standard plate thickness – flat ends, ends concave to pressure and convex to pressure: dished and flanged ends, conical ends	7
2.4	Mechanical design of tall pressure vessels : design of thin walled multi-course pressure vessels as per IS 2825 – Shells subject to external loads (wind and seismic)	3

CHT404	COMPREHENSIVE COURSE VIVA	CATEGORY	L	T	P	CREDIT
		PCC	1	0	0	1

Preamble: The objective of this Course viva is to ensure the basic knowledge of each student in the most fundamental core courses in the curriculum. The viva voce shall be conducted based on the core subjects studied from third to eighth semester. This course helps the learner to become competent in placement tests and other competitive examinations.

Guidelines

1. The course should be mapped with a faculty and classes shall be arranged for practicing questions based on the core courses listed in the curriculum.
2. The viva voce will be conducted by the same three member committee assigned for final project phase II evaluation. It comprises of Project coordinator, expert from Industry/research Institute and a senior faculty from a sister department.
3. The pass minimum for this course is 25.
4. The mark will be treated as internal and should be uploaded along with internal marks of other courses.
5. Comprehensive Viva should be conducted along with final project evaluation by the three member committee.

Mark Distribution

Total marks: 50, only CIE, minimum required to pass : 25 Marks

CHD416	PROJECT PHASE II	CATEGORY	L	T	P	CREDIT
		PWS	0	0	12	4

Preamble: The course 'Project Work' is mainly intended to evoke the innovation and invention skills in a student. The course will provide an opportunity to synthesize and apply the knowledge and analytical skills learned, to be developed as a prototype or simulation. The project extends to 2 semesters and will be evaluated in the 7th and 8th semester separately, based on the achieved objectives. One third of the project credits shall be completed in 7th semester and two third in 8th semester. It is recommended that the projects may be finalized in the thrust areas of the respective engineering stream or as interdisciplinary projects. Importance should be given to address societal problems and developing indigenous technologies.

Course Objectives

- To apply engineering knowledge in practical problem solving.
- To foster innovation in design of products, processes or systems.
- To develop creative thinking in finding viable solutions to engineering problems.

Course Outcomes [COs]: After successful completion of the course, the students will be able to:

CO1	Model and solve real world problems by applying knowledge across domains (Cognitive knowledge level: **Apply**).
CO2	Develop products, processes or technologies for sustainable and socially relevant applications (Cognitive knowledge level: **Apply**).
CO3	Function effectively as an individual and as a leader in diverse teams and to comprehend and execute designated tasks (Cognitive knowledge level: **Apply**).
CO4	Plan and execute tasks utilizing available resources within timelines, following ethical and professional norms (Cognitive knowledge level: **Apply**).
CO5	Identify technology/research gaps and propose innovative/creative solutions (Cognitive knowledge level: **Analyze**).
CO6	Organize and communicate technical and scientific findings effectively in written and oral forms (Cognitive knowledge level: **Apply**).

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	1	2	2	2	1	1	1	1	2
CO2	2	2	2		1	3	3	1	1		1	1
CO3									3	2	2	1
CO4					2			3	2	2	3	2
CO5	2	3	3	1	2							1
CO6					2			2	2	3	1	1

Abstract POs defined by National Board of Accreditation			
PO #	**Broad PO**	**PO#**	**Broad PO**
PO1	Engineering Knowledge	PO7	Environment and Sustainability
PO2	Problem Analysis	PO8	Ethics
PO3	Design/Development of solutions	PO9	Individual and team work
PO4	Conduct investigations of complex problems	PO0	Communication
PO5	Modern tool usage	PO11	Project Management and Finance
PO6	The Engineer and Society	PO12	Lifelong learning

PROJECT PHASE II

Phase 2 Targets

- In depth study of the topic assigned in the light of the report prepared under Phase - I;
- Review and finalization of the approach to the problem relating to the assigned topic.
- Preparing a detailed action plan for conducting the investigation, including teamwork.
- Detailed Analysis/ Modeling / 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.
- Presenting projects in Project Expos conducted by the University at the cluster level and/ or state level as well as others conducted in India and abroad.
- Filing Intellectual Property Rights (IPR) if applicable.
- Preparing a report in the standard format for being evaluated by the Department Assessment Board.
- Final project presentation and viva voce by the assessment board including the external expert.

Evaluation Guidelines & Rubrics

Total: 150 marks (Minimum required to pass: 75 marks).

- Project progress evaluation by guide: 30 Marks.
- Two interim evaluations by the Evaluation Committee: 50 Marks (25 marks for each evaluation).
- Final evaluation by the Final Evaluation committee: 40 Marks
- Quality of the report evaluated by the evaluation committee: 30 Marks

(The evaluation committee comprises HoD or a senior faculty member, Project coordinator and project supervisor. The final evaluation committee comprises of Project coordinator, expert from Industry/research/academic Institute and a senior faculty from a sister department).

Evaluation by the Guide

The guide/supervisor must monitor the progress being carried out by the project groups on regular basis. In case it is found that progress is unsatisfactory it should be reported to the Department Evaluation Committee for necessary action. The presence of each student in the group and their involvement in all stages of execution of the project shall be ensured by the guide. Project evaluation by the guide: 30 Marks. This mark shall be awarded to the students in his/her group by considering the following aspects:

Project Scheduling & Distribution of Work among Team members: Detailed and extensive Scheduling with timelines provided for each phase of project. Work breakdown structure well defined. (5)

Literature survey: Outstanding investigation in all aspects. (4)

Student's Diary/ Daily Log: The main purpose of writing daily diary is to cultivate the habit of documenting and to encourage the students to search for details. It develops the students' thought process and reasoning abilities. The students should record in the daily/weekly activity diary the day to day account of the observations, impressions, information gathered and suggestions given, if any. It should contain the sketches & drawings related to the observations made by the students. The daily/weekly activity diary shall be signed after every day/week by the guide. (7)

Individual Contribution: The contribution of each student at various stages. (9)

Completion of the project: The students should demonstrate the project to their respective guide. The guide shall verify the results and see that the objectives are met. (5)

EVALUATION RUBRICS for PROJECT Phase II: Interim Evaluation - 1						
No.	**Parameters**	**Marks**	**Poor**	**Fair**	**Very Good**	**Outstanding**
2-a	Novelty of idea, and Implementation scope [CO5] [Group Evaluation]	**5**	The project is not addressing any useful requirement. The idea is evolved into a non-implementable one. The work presented so far is lacking any amount of original work by the team.	Some of the aspects of the proposed idea can be implemented. There is still lack of originality in the work done so far by the team. The project is a regularly done theme/topic without any freshness in terms of specifications, features, and/or improvements.	Good evidence of an implementable project. There is some evidence for the originality of the work done by the team . There is fresh specifications/ features/improvements suggested by the team. The team is doing a design from fundamental principles, and there is some independent learning and engineering ingenuity.	The project has evolved into incorporating an outstandingly novel idea. Original work which is not yet reported anywhere else. Evidence for ingenious way of innovation which is also Implementable. Could be a patentable / publishable work.
			(0 – 1 Marks)	(2 – 3 Marks)	(4 Marks)	(5 Marks)
2-b	Effectiveness of task distribution among team members. [CO3] [Group Evaluation]	**5**	No task distribution of any kind. Members are still having no clue on what to do.	Task allocation done, but not effectively, some members do not have any idea of the tasks assigned. Some of the tasks were identified but not followed individually well.	Good evidence of task allocation being done, supported by project journal entries, identification of tasks through discussion etc. However, the task distribution seems to be skewed, and depends a few members heavily than others. Mostly the tasks are being followed by the individual members.	Excellent display of task identification and distribution backed by documentary evidence of team brainstorming, and project journal entries. All members are allocated tasks according to their capabilities, and as much as possible in an equal manner. The individual members are following the tasks in an excellent manner.
			(0 – 1 Marks)	(2 – 3 Marks)	(4 Marks)	(5 Marks)
2-c	Adherence to project schedule. [CO4] [Group Evaluation]	**5**	Little or no evidence of continued planning or scheduling of the project. The students did not stick to the plan what they were going to build nor plan on what materials / resources to use in the project. The students do not have any idea on the budget required even after the end of phase - I. No project journal kept or the journal.	There is some improvement in the primary plan prepared during phase I. There were some ideas on the materials /resources required, but not really thought out. The students have some idea on the finances required, but they have not formalized a budget plan. Schedules were not prepared. The project journal has no useful details on the project.	Good evidence of planning done and being followed up to a good extent after phase I. Materials were listed and thought out, but the plan wasn't followed completely. Schedules were prepared, but not detailed, and needs improvement. Project journal is presented but it is neither complete nor updated regularly.	Excellent evidence of enterprising and extensive project planning and follow-up since phase I. Continued use of project management/version control tool to track the project. Material procurement if applicable is progressing well. Tasks are updated and incorporated in the schedule. A well-kept project journal showed evidence for all the above, in addition to the interaction with the project guide.
			(0 - 1 Marks)	(2 - 3 Marks)	(4 Marks)	(5 Marks)

2-d	Interim Results. [CO6] [Group assessment]	**5**	There are no interim results to show.	The team showed some interim results, but they are not complete / consistent to the current stage, Some corrections are needed.	The interim results showed were good and mostly consistent/correct with respect to the current stage. There is room for improvement.	There were significant interim results presented which clearly shows the progress.
			(0 - 1 Marks)	(2 - 3 Marks)	(4 Marks)	(5 Marks)
2-e	Presentation [Individual assessment]	**5**	Very poor presentation and there is no interim results. The student has no idea about the project proposal.	Presentation is average, and the student has only a feeble idea about the team work.	Good presentation. Student has good idea about the team's project. The overall presentation quality is good.	Exceptionally good presentation. Student has excellent grasp of the project. The quality of presentation is outstanding.
			(0 - 1 Marks)	(2 - 3 Marks)	(4 Marks)	(5 Marks)
Phase-II Interim Evaluation - 1 Total Marks: 25						

EVALUATION RUBRICS for PROJECT Phase II: Interim Evaluation – 2

No	Parameters	Marks	Poor	Fair	Very Good	Outstanding
2-f	Application of engineering knowledge [CO1] [Individual Assessment]	**10**	The student does not show any evidence of applying engineering knowledge on the design and the methodology adopted. The student's contribution in application of engineering knowledge in the project is poor.	The student appears to apply some basic knowledge, but not able to show the design procedure and the methodologies adopted in a comprehensive manner.	The student is able to show some evidence of application of engineering knowledge in the design and development of the project to good extent.	Excellent knowledge in design procedure and its adaptation. The student is able to apply knowledge from engineering domains to the problem and develop solutions.
			(0 – 3 Marks)	(4 – 6 Marks)	(7 - 9 Marks)	(10 Marks)
2-g	Involvement of individual members [CO3] [Individual Assessment]	**5**	No evidence of any Individual participation in the project work.	There is evidence for some amount of individual contribution, but is limited to some of the superficial tasks.	The individual contribution is evident. The student has good amount of involvement in core activities of the project.	Evidence available for the student acting as the core technical lead and has excellent contribution to the project.
			(0 - 1 Marks)	(2 - 3 Marks)	(4 Marks)	(5 Marks)
2-h	Results and inferences upon execution [CO5] [Group Assessment]	**5**	None of the expected outcomes are achieved yet. The team is unable to derive any inferences on the failures/ issues observed. Any kind o f observations or studies are not made.	Only a few of the expected outcomes are achieved. A few inferences are made on the observed failures/issues. No further work suggested.	Many of the expected outcomes are achieved. Many observations and inferences are made, and attempts to identify the issues are done. Some suggestions are made for further work.	Most of the stated outcomes are met. Extensive studies are done and inferences drawn. Most of the failures are addressed and solutions suggested. Clear and valid suggestions made for further work.
			(0 - 1 Marks)	(2 - 3 Marks)	(4 Marks)	(5 Marks)
2-i	Documentation and presentation. .[CO6] [Individual assessment]	**5**	The individual student has no idea on the presentation of his/her part. The presentation is of poor quality.	Presentation's overall quality needs to be improved.	The individual's presentation performance is satisfactory.	The individual's presentation is done professionally and with great clarity. The individual's performance is excellent.
			(0 - 1 Marks)	(2 - 3 Marks)	(4 Marks)	(5 Marks)

Phase-II Interim Evaluation - 2 Total Marks: 25

EVALUATION RUBRICS for PROJECT Phase II: Final Evaluation

No	Parameters	Marks	Poor	Fair	Very Good	Outstanding
2-j	Engineering knowledge. [CO1] [Group Assessment]	10	The team does not show any evidence of applying engineering knowledge on the design and the methodology adopted.	The team is able to show some of the design procedure and the methodologies adopted, but not in a comprehensive manner.	The team is able to show evidence of application of engineering knowledge in the design and development of the project to good extent. There is scope for improvement.	Excellent knowledge in design procedure and its adaptation. The team is able to apply knowledge from engineering domains to the problem and develop an excellent solution.
			(0 – 3 Marks)	(4 – 6 Marks)	(7 - 9 Marks)	(10 Marks)
2-k	Relevance of the project with respect to societal and/or industrial needs. [Group Assessment] [CO2]	5	The project as a whole do not have any societal / industrial relevance at all.	The project has some relevance with respect to social and/or industrial application. The team has however made not much effort to explore further and make it better.	The project is relevant to the society and/or industry. The team is mostly successful in translating the problem into an engineering specification and managed to solve much of it.	The project is exceptionally relevant to society and/or industry. The team has made outstanding contribution while solving the problem in a professional and/ or ethical manner.
			(0 - 1 Marks)	(2 - 3 Marks)	(4 Marks)	(5 Marks)
2-i	Innovation / novelty / Creativity [CO5] [Group Assessment]	5	The project is not addressing any useful requirement. The idea is evolved into a non-implementable one. The work presented so far is lacking any amount of original work by the team.	Some of the aspects of the proposed idea appears to be practical. There is still lack of originality in the work done. The project is a regularly done theme/topic without any freshness in terms of specifications, features, and/ or improvements.	Good evidence of an implementable project. There is some evidence for the originality of the work done by the team. There is fresh specifications/ features/improvements suggested by the team. The team is doing a design from fundamental principles, and there is some independent learning and engineering ingenuity. Could be translated into a product / process if more work is done.	The project has evolved into incorporating an outstandingly novel idea. Original work which is not yet reported anywhere else. Evidence for ingenious way of innovation which is also Implementable. Could be a patentable publishable work.
			(0 - 1 Marks)	(2 - 3 Marks)	(4 Marks)	(5 Marks)
2-m	Quality of results / conclusions / solutions. [CO1] [Group Assessment]	10	None of the expected outcomes are achieved. The team is unable to derive any inferences on the failures/issues observed. Any kind of observations or studies is not made.	Only a few of the expected outcomes are achieved. A few inferences are made on the observed failures/issues. No further work suggested.	Many of the expected outcomes are achieved. Many observations and inferences are made, and attempts to identify the issues are done. Some suggestions are made for further work.	Most of the stated outcomes are met. Extensive studies are done and inferences drawn. Most of the failures are addressed and solutions suggested. Clear and valid suggestions made for further work.
			(0 – 3 Marks)	(4 – 6 Marks)	(7 - 9 Marks)	(10 Marks)

2-n	Presentation - Part I Preparation of slides. [CO6] [Group Assessment].	5	The presentation slides are shallow and in a clumsy format. It does not follow proper organization.	Presentation slides follow professional style formats to some extent. However, its organization is not very good. Language needs to be improved. All references are not cited properly, or acknowledged. Presentation slides needs to be more professional.	Presentation slides follow a good style format and there are only a few issues. Organization of the slides is good. Most of references are cited properly. The flow is good and team presentation is neatly organized. Some of the results are not clearly shown. There is room for improvement.	The presentation slides are exceptionally good. Neatly organized. All references cited properly. Diagrams/Figures, Tables and equations are properly numbered, and l i s ted. Results/ inferences clearly highlighted and readable.
			(0 - 1 Marks)	(2 - 3 Marks)	(4 Marks)	(5 Marks)
	Presentation - Part II: Individual Communication [CO6] [Individual Assessment].	5	The student is not communicating properly. Poor response to questions.	The student is able to explain some of the content. The student requires a lot of prompts to get to the idea. There are language issues.	Good presentation/ communication by the student. The student is able to explain most of the content very well. There are however, a few areas where the student shows lack of preparation. Language is better.	Clear and concise communication exhibited by the student. The presentation is outstanding. Very confident and tackles all the questions without hesitation. Exceptional traits of communicator.
			(0 - 1 Marks)	(2 - 3 Marks)	(4 Marks)	(5 Marks)
Phase-II Final Evaluation, Marks: 40						

EVALUATION RUBRICS for PROJECT Phase II: Report Evaluation						
Sl. No.	Parameters	Marks	Poor	Fair	Very Good	Outstanding
2-o	Report [CO6]	30	The prepared report is shallow and not as per standard format. It does not follow proper organization. Contains mostly unacknowledged content. Lack of effort in preparation is evident. References are not cited. Unprofessional and inconsistent formatting.	Project report follows the standard format to some extent. However, its organization is not very good. Language needs to be improved. All references are not cited properly in the report. There is lack of formatting consistency.	Project report shows evidence of systematic documentation. Report is mostly following the standard style format and there are only a few issues. Organization of the report is good. Mostly consistently formatted. Most of references/sources are cited/ acknowledged properly.	The report is exceptionally good. Neatly organized. All references cited properly. Diagrams/Figures, Tables and equations are properly numbered, and listed and clearly shown. Language is excellent and follows professional styles. Consistent formatting and exceptional readability.
			(0 - 11 Marks)	(12 - 18 Marks)	(19 - 28 Marks)	(29 - 30 Marks)
Phase - II Project Report Marks: 30						

SEMESTER VIII

PROGRAM ELECTIVE III

CHT414	AIR POLLUTION MONITORING AND CONTROL	CATEGORY	L	T	P	CREDIT
		PEC	2	1	0	3

Preamble: Air Pollution Monitoring & Control is the subject to understand about the atmospheric pollutant's standards, regulations, emission sources and their fate. The characteristics and nature of the atmosphere will impart the fate of natural as well as the anthropogenic air pollutants. Hence to provide a suitable solution, an engineer should know the fundamentals of atmospheric stability and air pollutant transport, characteristics of emission source and their control methods.

Prerequisite: Nil

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

CO 1	Define the sources, classifications, effects of air pollutants.
CO 2	Describe the ambient air quality standards as well as sampling and analysis of air pollutants from emission sources.
CO 3	Understand the concepts of atmospheric dispersion characteristics and nature based on lapse rate and inversion.
CO 4	Explain the selection strategies and types of equipment and its design to control particulates and gaseous pollutants.
CO 5	Explain the indoor air pollution sources, measurements, standards and 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					3
CO 2						3	3	3				3
CO 3	2	3					3					2
CO 4			3				3					2
CO 5							3					3

Assessment Pattern

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination**
	1	**2**	
Remember	20	20	50
Understand	20	20	30
Apply	10	10	20
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): Define the sources, classifications, effects of air pollutants.

1. Distinguish between primary and secondary air pollutants with examples.
2. Describe the characteristics of air pollutants from natural and anthropogenic sources.
3. Explain the impact of air pollution on human and vegetations.

Course Outcome 2 (CO2): Describe the ambient air quality standards as well as sampling and analysis of air pollutants from emission sources.

1. Distinguish ambient and stack sampling methods in air quality analysis with sketches.
2. Describe the significance of National Ambient Air Quality Standards.
3. Explain the emission criteria define by CPCB for various gaseous and particulate air pollutants from industries.
4. Explain air pollution laws, emission standards and regulations to control air pollution.

Course Outcome 3 (CO3): Understand the concepts of atmospheric dispersion characteristics and nature based on lapse rate and inversion.

1. Describe the temperature lapse rate and atmospheric stability.
2. Define adiabatic lapse rate? Derive expression for dry adiabatic lapse rate.
3. Explain, how plume behaviour will affect on the dilution of air pollutants in the atmosphere?
4. List out various air quality models. Write and explain the terms in Gauss Dispersion equation and Brigg's plume rise equations.
5. A chimney with a design stack height of 250 m and diameter of 3 m is emitting sulphur dioxide at a rate of 500 g/sec, at the stack altitude. The wind speed at the stack height is 2.7 m/sec with atmospheric stability class is E. Determine the plume rise (Δh) and effective stack height (H).

   Stack exit velocity: 5.5 m/s
   Stack exit temperature: 428.38 K
   Ambient temperature: 305.35 K.
   Take x = 5 km, y = 500 m, z = 75 m.

Course Outcome 4 (CO4): Explain the selection strategies and types of equipments and its design to control particulates and gaseous pollutants.

1. Describe the types of scrubbing processes to control gaseous emission.
2. Explain the operational and design modifications in the existing effluent gas treatment methods.
3. Describe any three equipments used for the collection of particulate pollutants with neat sketch.
4. Explain with sketches the working of a fabric filter. Compare the advantages and disadvantages of fabric filter.
5. Explain the control of air pollutant emission from mobile sources.
6. Explain Westvaco process to control SO_2 with neat diagram.

Course Outcome 5 (CO5): Explain the indoor air pollution sources, measurements, standards and control methods.

1. Classify the sources of indoor air pollution

Model Question Paper

QP CODE: **PAGES: 3**

Reg No: ______________

Name: ___________________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
EIGHTH SEMESTER B. TECH DEGREE EXAMINATION, MONTH & YEAR
Course Code: CHT414

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

AIR POLLUTION MONITORING AND CONTROL

PART – A

Answer All the Questions (10 x 3 = 30)

1. List out any six anthropogenic sources of air pollution.
2. Explain the effect of air pollution on human health.
3. Define dry adiabatic lapse rate and write the equation.
4. Explain the meteorological aspects of air pollutants.
5. Write the performance equation of Gravity settling chamber. Explain each term.
6. Explain the working principle of the cyclone separator with its equation of collection efficiency.
7. Compare the absorption and adsorption process in gaseous pollutant emission control.
8. Explain the factor affecting the working to bio-scrubbers.
9. What are some of the benefits beyond reduced health risks from high quality indoor air?
10. Examine your building operation. Make an inventory list of all the sources of contaminants that impact on indoor air quality. Determine which among these are likely to have first order effects on air quality.

PART – B

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

Module 1

11. Explain point source, line source, area source and volume source based on the emission direction of air pollutants. Give examples and describe their significance in quantification.

OR

12. With a neat sketch explain the components of stack sampling and analysis for gaseous and particulates pollutants.

Module-2

13. With neat sketches, explain atmospheric inversion and its significance in pollutant transport.

OR

14. A chimney with a design stack height of 250 m and diameter of 3 m is emitting sulphur dioxide at a rate of 500 g/sec, at the stack altitude. The wind speed at the stack height is 2.7 m/sec with atmospheric stability class is E. Determine the plume rise (Δh) and effective stack height (H).

    Stack exit velocity: 5.5 m/s
    Stack exit temperature: 428.38 K
    Ambient temperature: 305.35 K.

Take x = 5 km, y = 500 m, z = 75 m.

Module 3

15. (a) Derive the expression for collection efficiency of an electrostatic precipitator in terms of gas flow rate and precipitator size.
    (b) With a neat schematic diagram explain the design features and working of a venturi scrubber.

OR

16. Explain the factors considered during the selection of types of equipment to control air pollution in industries.

Module 4

17. Explain the design features and working of the Venturi scrubber with a neat schematic diagram.

OR

18. Explain the advantages and disadvantages of bio-scrubbers and bio-filters.

Module 5

19. (a) Air samples are collected over an 8 hour work shift for MEK. Measurements showed 3 ppm after 2 hours, 24 ppm after 4.5 hours, 12 ppm after 6 hours, and 2 ppm after 8 hours. Calculate the TWA concentration and compare this value against the OSHA safe level of exposure.
    (b) Develop a checklist f items that should be addressed in an IAQ audit.

OR

20. Describe the working of following instruments for indoor air quality testing.
    (i) Carbon monoxide testers
    (ii) Oxygen indicator
    (iii) Indicator (Calorimetric) tubes

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Syllabus

Module 1: Air Quality (7 Hrs.)

Structure and composition of Atmosphere – Definition, Scope and Scales of Air Pollution- Sources and classification of air pollutants-Effect on human health, vegetation, animals, property, aesthetic value and visibility- Ambient Air Quality and Emission standards–Ambient and stack sampling and Analysis of Particulate and Gaseous Pollutants.

Module 2: Atmospheric Dispersion of Air Pollutant (7 Hrs.)

Effects of meteorology on Air Pollution - Fundamentals, Atmospheric stability- Dry adiabatic lapse rate derivation, Inversion, Wind profiles and stack plume patterns- Atmospheric Diffusion Theories – Dispersion models, Plume Rise-Numerical Problems.

Module 3: Control of Particulate Contaminants (7 Hrs.)

Gas Particle Interaction – Working principle, Design and performance equations of Gravity Separators, Centrifugal separators, Fabric filters, Particulate Scrubbers, Electrostatic Precipitators – Operational Considerations- Factors affecting Selection of Control Equipment.

Module 4: Control of Gaseous Contaminants (7 Hrs.)

Working principle, Design and performance equations of absorption, Adsorption, condensation, Incineration, Bio scrubbers, Venturi scrubber- Bio filters – Process control and Monitoring – Operational Considerations- Factors affecting Selection of Control Equipment–CO_2 capturing, Hydrocarbon removal.

Module 5: Indoor Air Quality Management (7 Hrs.)
Sources types and control of indoor air pollutants, sick building syndrome types – HVAC system-IAQ issues and impacts on occupants—Developing an IAQ profile-Diagnose IAQ problem-Control-Quantification and Measurement.

Text Books

1. Lawrence K. Wang, Norman C. Pareira, Yung Tse Hung, *Air Pollution Control Engineering*, Tokyo, 2004.
2. Noel de Nevers, *Air Pollution Control Engineering*, Mc Graw Hill, New York, 1995.
3. Anjaneyulu. Y, *Air Pollution and Control Technologies*, Allied Publishers (P) Ltd., India
4. 2002.
5. C.S.Rao, *Environmental Pollution Control Engineering*, Wiley Eastern Ltd, Delhi.
6. Nicholas P. Cheremisinoff, Handbook of Air Pollution Prevention and Control, Butterworth and Heinemann, Elsevier Science (USA), 2002.

Reference Books

1. David H.F. Liu, Bela G. Liptak, *Air Pollution*, Lweis Publishers, 2000.
2. Arthur C.Stern, *Air Pollution (Vol.I – Vol.VIII)*, Academic Press, 2006.
3. Wayne T.Davis, *Air Pollution Engineering Manual* , John Wiley & Sons, Inc.,2000.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Module 1**	**7**
1.1	Structure and composition of Atmosphere – Definition, Scope and Scales of Air Pollution.	1
1.2	Sources and classification of air pollutants.	2
1.3	Effect on human health, vegetation, animals, property, aesthetic value and visibility.	1
1.4	Ambient Air Quality and Emission standards.	1
1.5	Ambient and stack sampling and Analysis of Particulate and Gaseous Pollutants.	2
2	**Module 2 (7 Hrs.)**	
2.1	Effects of meteorology on Air Pollution – Fundamentals.	2
2.2	Atmospheric stability- Dry adiabatic lapse rate derivation.	1
2.3	Inversion, Wind profiles and stack plume patterns.	1
24	Atmospheric Diffusion Theories.	1
2.5	Dispersion models, Plume Rise-Numerical Problems.	2
3	**Module 3 (7 Hrs.)**	
3.1	Gas Particle Interaction principle in separation.	1
3.2	Design and performance equations	1
3.3	Gravity Separators, Centrifugal separators,	1
3.4	Particulate Scrubbers, Fabric filters	1
3.5	Electrostatic Precipitators	1
3.6	Operational Considerations.	1
3.7	Factors affecting Selection of Control Equipment.	1
4	**Module 4 (7 Hrs.)**	
4.1	Working principle, Design and performance equations of absorption, Adsorption, condensation.	1
4.2	Incineration, Bio scrubbers, Venturi scrubber- Bio filters	2
4.3	Process control and Monitoring – Operational Considerations- Factors affecting Selection of Control Equipment	2
4.4	CO_2 capturing, Hydrocarbon removal	2
5	**Module 5 (7 Hrs.)**	
5.1	Sources types and control of indoor air pollutants	1
5.2	sick building syndrome types	1
5.3	HVAC system	1
5.4	IAQ issues and impacts on occupants	1
5.5	Developing an IAQ profile-Diagnose IAQ problem	1
5.6	Control Equipments for indoor air pollutants.	1
5.7	Quantification and Measurement	1

CHT424	PETROLEUM REFINERY ENGINEERING	CATEGORY	L	T	P	CREDIT
		PEC	2	1	0	3

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 preliminary, 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	Select various techniques to improve the quality of gasoline to meet the Bharath stage norms and treatment techniques to other petroleum products.
CO 5	Identify 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											
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	20
Understand	20	20	30
Apply	20	20	50
Analyse			
Evaluate			
Create			

Mark distribution

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

Continuous Internal Evaluation Pattern:

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

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, 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. What is 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 Select 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 identify 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
EIGHTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR
Course Code: CHT424
Max. Marks: 100 **Duration: 3 Hours**

CHT 424 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 1

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)

OR

12. a) Discuss about the evaluation of crude oil.
    b) What is GRM and how it is calculated. (9+5 = 14 marks)

MODULE 2

13. With neat diagram explain the working of Electric desalter. What are the parameters affecting the performance of Electric desalter? (14 marks)

OR

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 3

15. a) With neat diagram explain the working of Delayed coker.

b) What are the advantages of Catalytic conversion process? (9+5 = 14 marks)

OR

16. a) With neat diagram explain the working of Hydrocracker. (8 marks)

b) What are the process parameters for hydro cracking? Explain. (6 marks)

MODULE 4

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 marks)

OR

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 5

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)

OR

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: Introduction of Origin of Crude oil, Evaluation, Refining (8 Hrs.)

Origin and formation of crude oil. Oil exploration and drilling. 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.

Module 2: Preliminary and Primary refinery operations (6 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- Prefractionator, Atmospheric topping unit, Vacuum distillation unit.

Module 3 Cracking and Coking Operations (7 Hrs.)

Thermal Conversion process. Thermal cracking, Visbreaking, Coking. Types and uses of petroleum coke.

Catalytic conversion process-Catalytic cracking-Types of Catalyst. Process description of Fluid Catalytic cracking unit. Process variables. Latest developments in the catalytic cracking process. Process description and applications of Hydro cracking.

Module 4 Reforming and Treatment of Light End products (7 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. Hydrogen production in Refinery, 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: Treatment and Test Methods of Petroleum Products (7 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. Baskara Rao B.K, Modern Petroleum Refinery Process, Oxford& IBM
2. Dr.Ram Prasad, Petroleum Refining Technology, Khanna Publishers

References:

1. Dr.Kochu Baby Manjooran S, Modern Petroleum Chemistry
2. James H.Garry Glenn E. Handwerk Mark J.Kaiser, Petroleum Refinery Technology and Economics, CRC Press, Taylor and Francis group.
3. I D Mall, Petrochemical Process technology, Macmillan
4. Nelson W.L, Petroleum Refinery Engineering, McGraw Hill
5. Gopala Rao M & Sitting M, Drydens Outline of Chemical Technology, Affiliated East West Press

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Module 1**	**8**
1.1	Origin and formation of crude oil	1
1.2	Oil exploration and drilling	1
1.3	Storage and transportation of crude oil and products	1
1.4	Classification, Composition and Evaluation of oil stock	3
1.5	Status of Petroleum industry in India and Classification of petroleum refinery	1
1.6	Fundamentals of Refinery economics	1
2	**Module 2**	**6**
2.1	Impurities in crude oil, Dehydration and desalting of crude	1
2.2	Electric Desalter- Types, Process, factors affecting electric desalter	1
2.3	Furnaces and its operations	1
2.4	Distillation of crude- Prefractionator, Atmospheric topping unit.	2
2.5	Vacuum distillation unit	1
3	**Module 3**	**7**
3.1	Thermal cracking and its application	1
3.2	Visbreaking	1
3.3	Coking	1
3.4	Types, properties and uses of petroleum coke	1
3.5	Catalytic cracking-Types of Catalyst	1
3.6	Fluid catalytic Cracking unit	1
3.7	Process description and applications of Hydro cracking	1
4	**Module 4**	**7**
4.1	Catalytic reforming- Catalyst-Process description	1
4.2	Catalyst, Process variables, Process description and application of Alkylation, Isomerisation	2
4.3	Supporting process in Refinery- Hydrogen production, Acid gas removal and Sulphur recovery process- Modified Claus process.	2
4.4	Treatment of gasoline- Copper Chloride process and Merox sweetening. Treatment of LPG	1
4.6	Diesel Hydro desulphurisation (DHDS) and production of Ultra low sulphur Diesel (ULSD), Bharathe stage norms of Diesel and Gasoline	1
5	**Module 5**	**7**
5.1	Treatment of Kerosene- Edeleanu process. Production and treatment of Lube- Phenol extraction	2
5.2	Dewaxing methods- Chilling and pressing and MEK dewaxing.	1
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

CHT434	COMPUTATIONAL FLUID DYNAMICS	CATEGORY	L	T	P	CREDIT
		PEC	2	1	0	3

Preamble: Computational Fluid Dynamics (CFD) is used as a research and design tool. CFD can be applied to majority of engineering problems such as chemical and mineral processing, environmental problems, aerospace fields, naval architecture and biomedical engineering. It can be used as an education tool to learn basic thermal-fluid science. With decreasing hardware costs and rapid computing times, CFD is easy – to use and reliable tool to produce accurate results.

Prerequisite: Fluid Mechanics and Applied Mathematics

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

CO 1	Describe basic CFD concepts and procedure of CFD solution
CO 2	Apply knowledge of basic science and engineering fundamentals to solve practical problems
CO 3	Solve the governing equations for fluid flow numerically.
CO 4	Implement grid generation, assess stability and conduct a grid convergence assessment.
CO 5	Apply turbulence models to engineering fluid flow 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	2							
CO 4	3	3	3	2	2						3	
CO 5	3	3	3	2	2						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): Describe basic CFD concepts and procedure of CFD solution

1. What are the main elements involved in a complete CFD analysis?
2. What are meanings of boundary conditions and how are they applied?

Course Outcome 2 (CO2): Apply knowledge of basic science and engineering fundamentals to solve practical problems

1. Determine velocity profile for steady incompressible laminar flow through the space between two parallel plates
2. For steady heat conduction across an infinite long slab, determine analytical expression using boundary conditions: at $x = 0$, $T = T_o$, at $x = L$, $T = T_L$

Course Outcome 3 (CO3): Solve the governing equations for fluid flow numerically

1. Explain implicit and explicit methods
2. Describe Crank Nicholson scheme

Course Outcome 4 (CO4): Implement grid generation, assess stability and conduct a grid convergence assessment

1. Write note on grid independence

Course Outcome 5 (CO5): Apply turbulence models to engineering fluid flow problems.

1. Discuss on k-ε turbulence model
2. What is energy cascade process in turbulence?

Model Question Paper

QP CODE: **PAGES:**

Reg No: _______________

Name: ____________________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

EIGHTH SEMESTER B. TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: CHT434

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

COMPUTATIONAL FLUID DYNAMICS

PART – A

Answer All the Questions (10 x 3 = 30)

1. Explain well-posedness.
2. What is the main purpose of a CFD solver?
3. Explain Neumann and Dirichlet boundary conditions with example.
4. Write on turbulence modelling in CFD.
5. What do you mean by consistency?
6. Describe the concept of explicit and implicit methods.
7. Write note on TDMA.
8. Write one-dimensional and two-dimensional steady state diffusion equations.
9. How structured grid is different from an unstructured grid? Explain.
10. What is grid independence?

PART – B

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

Module 1

11. Appropriate use of boundary conditions has a significant role in CFD solution. Comment on the statement. Explain implementation of boundary conditions for a CFD problem.

OR

12. Explain classification of PDEs

Module 2

13. Consider a laminar boundary layer that can be approximated as having velocity profile $u(x) = \frac{Uy}{\delta}$, where $\delta = cx^{1/2}$, c is constant, U is free stream velocity and δ is boundary layer thickness. For two dimensional fluid flow over a flat plate, determine the vertical component of velocity inside the boundary layer.

OR

14. Determine velocity profile for steady incompressible laminar flow through the parallel plate channel. Assume fully developed flow and constant properties

Module 3

15. Write note on Crank Nicholson scheme

OR

16. What is forward, backward and central difference? Explain

Module 4

17. Consider the problem of source free conduction in an insulated rod of 0.5 m, whose ends are kept at 100°C and 500°C. This one-dimensional problem is governed by $\frac{d}{dx}\left(k\frac{dT}{dx}\right) = 0$. Obtain discretized equations for the boundary nodes if thermal conductivity k = 1000 W/mK and cross sectional area = 10 x 10^{-3} m^2. Take node spacing as 0.1 m

OR

18. Explain the fundamental properties of discretization schemes, which are needed to make numerical results physically realistic.

Module 5

19. Explain stepwise procedure of SIMPLE algorithm

OR

20. Write the benefits of using staggered grids. Explain pressure correction method

****

Syllabus

Module 1: Introduction **(8 Hrs.)**

Introduction: Need of CFD as an analysis tool, comparison of experimental, theoretical and computational approaches, Applications – automobile, environmental engineering, chemical engineering, CFD software packages and tools. CFD solution procedure: pre-processing, numerical solution – CFD solver, post processing.

Ordinary and partial differential equations, classification of partial differential equations (PDE): physical classification – equilibrium and marching problems; mathematical classification – hyperbolic, parabolic and elliptic PDEs, well posed problems.

Module 2: Review of governing equations **(7 Hrs.)**

Review of governing equations: Continuity equation**,** Momentum equation, Energy equation, Navier – Stokes equation, generic form of governing equations, boundary conditions - types of boundary conditions: Neumann, Dirichlet, Robin, mixed boundary condition. Turbulence modelling – k-ε turbulence model.

Module 3: Basic concepts of CFD **(6 Hrs.)**

Basic concepts of CFD: Introduction to discretization, Finite difference approximation of a derivative, discretization of differential equations using finite differences, consistency, convergence and stability (concepts alone), concept of explicit and implicit methods, Crank Nicholson scheme (FTCS only).

Module 4: Finite volume discretization **(7 Hrs.)**

Finite Volume Discretization: Diffusion problem, convection-diffusion problem, properties of discretization schemes – conservativeness, boundedness, transportiveness.

Solution to discretized equations: TDMA, Jacobi, Gauss-Seidel, Gauss elimination methods.

Module 5: Detailed study of Navier-Stokes Equation **(7 Hrs.)**

Detailed study of Navier stokes Equation-Solution of the Navier Stokes Equations-Discretization of convective, viscous, pressure and body force terms-conservation properties-grid arrangement-colocated and staggered pressure equation and its solutions—implicit and explicit methods-implicit pressure correction methods-Fractional Step method-SIMPLE algorithm for a colocated Variable arrangement.

Grid generation: structured and unstructured grid, grid spacing, Cartesian and curvilinear grids, grid independence, hybrid grid.

Text Books

1. John C Tannehill, D A Anderson, R H Pletcher, Computational fluid Mechanics and Heat transfer, , Taylor & Francis Publishers.
2. John D Anderson, Computational Fluid Dynamics – The basics with applications, Mc GrawHill.
3. H Versteeg, M Malasekara, An introduction to Computational Fluid Dynamics, Pearson.

Reference Books

1. Vivek V. Ranade, Computational Fluid Dynamics for Reactor Engineering De Gruyter, 1995.
2. K Muralidhar and Sundararajan, Computational Fluid flow and Heat transfer,
3. Suhas V Patankar, Numerical heat transfer and fluid flow.
4. Pradeep Niyogi, S K Chakrabarthy, M K Laha, Pearson, Introduction to Computational Fluid Dynamics
5. Gautam Biswas, Somenath Mukherjee, Narosa ,Computational Fluid Dynamics
6. Sreenivas Jayanti, Computational fluid dynamics for Engineers and Scientists, Springer.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Module 1**	**8**
1.1	Need of CFD, advantages of CFD method, applications,	1
1.2	solution procedure – pre-processing, solver, post processing – geometry, meshing, implementation of boundary conditions etc., computer graphic techniques	2
1.3	PDE, classification,	1
1.4	Equilibrium & marching problems	1
1.5	Hyperbolic, elliptic, parabolic PDE	1
1.6	Well posed problems	2
2	**Module 2**	**7**
2.1	Continuity, momentum and energy equation	2
2.2	Navier – Stokes equation	1
2.3	Generic form of governing equation	1
24	Boundary conditions – need, various types with examples	1
2.5	Turbulence modelling - k-ε turbulence model	2
3	**Module 3**	**6**
3.1	Discretization , finite difference approximation of a derivative, truncation error	1
3.2	Discretization of equations using finite difference	1
3.3	Concept of consistency, convergence and stability	1
3.4	Explicit and implicit methods	1
3.5	Crank- Nicolson scheme - FTCS	1
4	**Module 4**	**7**
4.1	Diffusion problem	1
4.2	Convection-diffusion problem	1
4.3	Properties of discretization schemes - conservativeness, boundedness, transportiveness.	1
4.4	Solution methods – TDMA, Jacobi	2
4.5	Gauss Siedel and Gauss elimination	2
5	**Module 5**	**7**

5.1	Solution of Navier Stokes equations	1
5.2	Discretization of convective, viscous, pressure and body force terms	2
5.3	conservation properties-grid arrangement	1
5.4	staggered pressure equation and its solutions—implicit and explicit methods –	1
5.5	implicit pressure correction method	1
5.6	Fractional Step method-SIMPLE algorithm for a colocated Variable arrangement	1
5.7	Grid generation – structured & unstructured grids, grid spacing, Cartesian and curvilinear grids, grid independence, hybrid grid	1

CHT444	POLYMER TECHNOLOGY	CATEGORY	L	T	P	CREDIT
		PEC	2	1	0	3

Preamble: This course will provide fundamental knowledge of polymers which includes- classification, properties and applications. This course also incorporates the study on the processing and testing the properties of different polymers, which will enable the students in selecting suitable polymers for engineering applications and help them to carry out research in the area of material development.

Prerequisite: Nil

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

CO 1	Understand the fundamentals and mechanisms of polymerisation, classification and methods of polymerisation.
CO 2	Describe methods to find out average molecular weight of polymers and understand the factors affecting polymer properties
CO 3	Summarize the manufacture, properties and engineering applications of different polymeric materials.
CO 4	Analyse the rheology and mechanical properties of polymers and to understand the functions of additives used in polymers.
CO 5	Explain the processing methods of plastics and elastomers.
CO6	Describe the types, properties and applications of nanocomposites.

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						2					
CO 5	3					3						2
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 fundamentals and mechanisms of polymerisation, classification and methods of polymerisation.

1. List the types of polymerisation based on thermal response with examples.
2. Outline the method of suspension polymerisation.
3. Derive the copolymer equation.

Course Outcome 2 (CO2): Describe methods to find out average molecular weight of polymers and understand the factors affecting polymer properties

1. What is the practical significance of molecular weight distribution in polymers?
2. Give details of determining the molecular weight of polymers by solution viscosity.
3. Discuss the types of polymer degradation giving examples.

Course Outcome 3(CO3): Summarize the manufacture, properties and engineering applications of different polymeric materials.

1. What is a resol type of PF resin? Explain the reactions involved in the formation of resole**.**
2. What are silicon polymers? Write the relevant reactions in the preparation of silicone polymers.
3. Compare the properties of butyl and nitrile rubbers.

Course Outcome 4 (CO4): Analyse the rheology and mechanical properties of polymers and to understand the functions of additives used in polymers.

1. Describe different models of viscoelastic behaviour of polymers.
2. Define the tensile strength of polymers. How is it measured?
3. Write a note on capillary rheometers.
4. Write the functions of antioxidants giving two examples.
5. Briefly explain the functions of lubricants and flow promoters.

Course Outcome 5 (CO5): Explain the processing methods of plastics and elastomers.

1. With a neat diagram, explain the process of injection moulding.
2. Write a note on calendaring.
3. Describe wet, dry and melt spinning methods with proper diagrams.
4. Describe the process of vulcanization of rubber.

Course Outcome 6 (CO6): Describe the types, properties and applications of nanocomposites

1. Illustrate the properties and applications of nanocomposites.
2. Outline the merits and demerits of nanocomposites.

Model Question Paper

QP CODE: **PAGES:3**

Reg No:______________

Name :______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
EIGHTH SEMESTER B. TECH DEGREE EXAMINATION, MONTH & YEAR
Course Code: CHT444

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

CHT444 POLYMER TECHNOLOGY

(2019-Scheme)

PART A

(Answer all questions, each question carries 3 marks)

1. Classify polymers based on their structure.
2. Distinguish between addition and condensation polymerisation
3. Give three terms of expressing the molecular weight of a polymer.
4. Illustrate the types of copolymers with examples.
5. What is glass transition temperature? List the factors affecting T_g.
6. Discuss the thermal degradation of polymers.
7. Describe the method to estimate the tensile strength of polymers.
8. Explain why Nylon exhibits high melting point?
9. Discuss the role of stabilisers in PVC compounding?
10. What are nanocomposites? List the types of nanocomposites giving examples.

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) Outline the mechanism of free radical polymerisations with a suitable example.

12. a) Describe bulk polymerisation technique. Write its merits and demerits

Module –2

13. a) Give details of molecular weight determination by Light scattering method.

b) Write a note on crystallinity of polymers.

14. Explain the details of determining molecular weight of polymers by solution viscosity.

Module –3

15. Describe the manufacture of poly vinyl chloride. What are the properties of this plastic for commercial importance?

16. a) Discuss the method of polyester manufacturing.

    b) Write a note on bioplastics.

Module –4

17. Discuss the viscoelastic behaviour of polymers.

18. How are the flow properties of polymers measured? Discuss the importance of stress relaxation and creep.

Module –5

19. a) How injection moulding of thermoplastic differ from that of thermoset?

    b) Discuss the salient features of elastomers.

20. a) What is thermoforming? Write the various techniques of thermoforming.

    b) Discuss the classification of nanocomposites giving examples.

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Syllabus

Module 1: Introduction to Polymers, Classification and kinetics (7Hrs)

Introduction to polymers-monomer, functionality, classification of polymer based on source, structure, application, thermal behaviour, mode of polymerization. Kinetics of step growth polymerisation, addition polymerization and Ionic polymerisations – anionic and cationic polymerization. Copolymerisation-Different types of copolymers – Characteristics. Methods of polymerization – bulk, solution, suspension and emulsion polymerization.

Module 2: Molecular weight of polymers (7 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-sedimentation methods. Molecular weight distribution curve. Factors affecting polymer properties – crystallinity – orientation treatment – solubility of polymers – glass transition temperature – types of polymer degradation.

Module 3: Manufacture, properties and applications Bioplastics, Elastomers (7 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), Polyhydroxy Butyrate (PHB), Cellulose Acetate. Elastomers-Butyl rubber -Nitrile rubber.

Module 4: Rheology and Testing of polymers and additives used (7 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 mechanical properties like tensile strength, flexural strength, hardness and impact strength of polymers. Additives 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: Processing of plastics and elastomers (7 Hrs)

Plastic processing technology – 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 polymer nano composites-types and properties of nanofillers applications.

Text/Reference Books

1. Billmeyer F.W., Text book of polymer science, John Wiley.
2. Gowariker V.R. Polymer Science, New Age.
3. Premamoy Ghosh., Polymer Science and Technology, Tata Mc Graw Hill.
4. Rodrigues F., Principles of polymer systems, Tata Mc Graw Hill
5. Shah V.H., Handbook of plastic testing technology, Wiley, 1998

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Module 1**	**7**
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 step growth polymerization	1
1.4	Kinetics of addition polymerization- free radical polymerization	1
1.5	Ionic polymerisation-anionic and cationic polymerization	1
1.6	Different types of copolymers- Characteristic features, Copolymer equation.	1
1.7	Methods of polymerization – bulk, solution, suspension and emulsion polymerization	1
2	**Module 2**	**7**
2.1	Weight average and number average molecular weight-Definition and types	1
2.2	Experimental methods of molecular weight determination- end group analysis	1
2.3	Determination of molecular weight by Light scattering method ,	1
2.4	Viscometry and Sedimentation methods,	1
2.5	Molecular weight distribution curve	1
2.6	Factors affecting polymer properties	1
2.7	Types of polymer degradation	1

3	**Module 3**	7
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	1
3.4	Polyesters – silicones, Bioplastics- Poly lactic acid.	1
3.5	Elastomers-Natural rubber- Butyl rubber- Nitrile rubber.	1
4	**Module 4**	**7**
4.1	Properties of polymers – rheology- – apparent viscosity -viscous flow - stress strain behaviour of elastomers	1
4.2	Viscoelasticity stress relaxation and creep	1
4.3	Measurement of rheological properties – melt flow index (MFI) – capillary rheometers.	1
4.4	Testing of tensile strength, flexural strength, hardness and impact strength of polymers	2
4.5	Effect of additives used; plasticizers; colourants, antioxidants; ultraviolet absorbers and heat stabilisers	1
4.6	Antistatic agents; flame retardants; blowing agents, Lubricants and fillers	1
5	**Module 5**	**7**
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.	1
5.5	Introduction to nanocomposites	1

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CHT454	PROCESS UTILITY AND PIPING ENGINEERING	CATEGORY	L	T	P	CREDIT
		PEC	2	1	0	3

Preamble: Aim of this course is to give the student a thorough knowledge of different process systems that are essential for the working of any chemical or related industry. The course also provides a brief overview of piping systems employed in industries.

Prerequisite: Basic knowledge in Momentum, Heat and Mass Transfer Operations

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

CO1	Identify and describe the major types, processes and associated equipments of utility systems employed in industries.
CO2	Compute the power rating of equipments and select the rating of instruments and process auxiliaries.
CO3	Perform mathematical calculations involved in steam generation, psychrometry and refrigeration operations.
CO4	Select the relevant pipes for various chemical processes and state piping colour code for a given process fluid.
CO5	Identify different types of pipes, joints, fittings and related accessories used in process plants.
CO6	Choose relevant insulation material for piping 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	2									
CO 3	3	3	2									
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	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): Identify and describe the major types, processes and associated equipments of utility systems employed in industries.

1. State and explain any seven requirements of a good water distribution system.
2. Differentiate primary and secondary plant utility systems

Course Outcome 2 (CO2): Compute the power rating of equipments and select the rating of instruments and process auxiliaries.

1. Classify different types of vacuum pumps and explain performance characteristics.
2. A single stage compressor is used to compress 800 m^3/hr of CO_2 measured at 288 K and 1 bar from its initial stage of 0.5 bar and 300 K to a final pressure of 1.5 bars. A volumetric efficiency of 75 % and a compression efficiency of 85 % may be assumed. Assuming adiabatic compression, calculate the power required for driving the compressor, the piston displacement in m^3/s and the discharge temperature.

Course Outcome 3 (CO3): Perform mathematical calculations involved in steam generation, psychrometry and refrigeration operations.

1. Define Psychrometry? Enumerate and explain different psychrometric processes and represent them on a psychrometric chart.
2. Distinguish economy and capacity with respect to boilers? List and explain the different types of boilers used in chemical industry.
3. A refrigeration system has working temperature of –27°C and 37°C. Find out actual COP, if it is 70% of Maximum.

Course Outcome 4 (CO4): Select the relevant pipes for various chemical processes and state piping colour code for a given process fluid.

1. State and explain some of the general considerations that should be evaluated when selecting and applying materials for piping.
2. What is an equivalent pipe? Write the expression for equivalent size of a compound pipe.

Course Outcome 5 (CO5): Identify different types of pipes, joints, fittings and related accessories used in process plants.

1. Explain the effect of pipe fitting on pressure losses.
2. Give the significance of hangers and supports in pipeline design. List different types of pipe hangers and pipe supports

Course Outcome 6 (CO6): Choose relevant insulation material for piping systems.

1. Classify different insulation materials based on the application in commercial piping industry.
2. Explain economic thickness of insulation. List any two parameters required to evaluate economic thickness of insulation.

Model Question Paper

QP CODE: **PAGES: 2**

Reg No: ______________

Name: ______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

EIGHTH SEMESTER B. TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: CHT454

PROCESS UTILITY AND PIPING ENGINEERING

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

PART – A

Answer All the Questions (10 x 3 = 30)

1. Draw a neat-labeled sketch of vapour compression refrigeration systems.
2. Give the need to provide interstage cooling in multistage compression process.
3. List any four factors that affect the performance of cooling towers employed in industries.
4. Give the application of cryogenic temperature in chemical industry.
5. List any two methods by which the steam economy can be improved.
6. Explain the principle of recuperators.
7. List any four desirable properties of piping materials.
8. Differentiate between code and standard with respect to piping engineering.
9. Classify Non-Newtonian fluids and give example for each type.
10. List any four desirable properties of a good insulating material.

PART – B

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

Module 1

11. Explain the mechanical draft and the natural draft cooling towers employed in industries and compare their relative merits and demerits

OR

12. State and explain any seven requirements of a good water distribution system.

Module II

13. With a neat sketch, explain single acting reciprocating compressor? Differentiate reciprocating and rotary compressors.

OR

14. Classify different types of vacuum pumps and explain performance characteristics.

Module III

15. Explain the methods employed for detecting and releasing condensate by mechanical, thermostatic and thermodynamic types of steam traps

OR

16. Explain the terms economy and capacity of boilers. List and explain the piping and accessories used in the transportation of steam.

Module IV

17. Explain why, humidification and dehumidification become necessary in air water systems. Bring out the difference between the two. Briefly describe the equipments for these operations.

OR

18. Enumerate the classification of refrigerants. List the desirable properties of refrigerants. Name some common refrigerants generally used in refrigeration systems.

Module V

19. List out the major codes and standards providing engineering bodies in piping? Explain any one in detail.

OR

20. List the functions and properties of gaskets. Differentiate between flat ring and laminated type gaskets

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Syllabus

Module 1 (5 Hours)

Process Utility Systems: Classification of process utility systems, Importance of process utilities in chemical industries and plants.
Water as a utility in process industries: Sources of water, hard and soft water, requisites of industrial water and its uses, methods of water treatment, storage and distribution of water, recycle and conservation of water.
Cooling Tower: Types and performance evaluation.

Module 2 (6 Hours)

Introduction to Fuels, Properties of Fuel oil, Coal and Gas, Storage, handling and preparation of fuels, Principles of Combustion, Combustion of Oil, Coal and Gas.
Compressed air system: Types of air compressors, Compressor efficiency, Efficient compressor operation, Compressed air system components, Capacity assessment, Leakage test, Factors affecting the performance and efficiency of compressors.
Vacuum Pumps: Types of vacuum pumps and their performance characteristics.

Module 3 (8 Hours)

Steam System: Steam and its importance, Properties of steam, Problems based on enthalpy calculation for wet steam, dry saturated steam and superheated steam.
Boilers: Types of steam generators/boilers, Combustion in boilers, Performance evaluation, Analysis of losses, Feed water treatment, Blow down, Energy conservation opportunities, Boilers Act.
Steam handling and distribution: Steam distribution system, Assessment of steam distribution losses, Steam economy, Steam traps, Condensate and flash steam recovery system, Identifying opportunities for energy savings.
Waste Heat Recovery: Classification, Advantages and applications, commercially viable waste heat recovery devices, Saving potential.

Module 4 (6 Hours)

Refrigeration and Ventilation: Principles of refrigeration, vapour compression and vapour absorption refrigeration cycles, types of refrigerants and their importance. Production of cryogenic temperatures.
Characteristics of Air-water systems. Humidification and Dehumidification equipments. Exhaust & Ventilation.

Module 5 (10 Hours)

Introduction to Piping: Classification of pipes, pipe materials, pipe sizing, pipe wall thickness, schedule number, codes and standards. Piping colour codes as per types of fluid passing through pipes.

Piping Components: Pipes, Fittings, Flanges, Gaskets, Bolting and Valves.

Pipe fittings: Functions and properties, types of pipe fittings and their selection.

Gaskets: Functions and properties, types of gaskets and their selection.

Valves: Types of valves, selection criteria of valves for various systems.

Piping insulation: Insulation materials, estimating thickness of insulation, critical thickness of insulation, optimal thickness of insulation.

Reference Books:

1. Jack Broughton, “Process utility systems”, Institution of Chem. Engineers, U.K.
2. M.S. Peters and Timmerhaus, “Plant design and Economics for Chemical Engineers”, Mc Graw Hill, 3rd Edition.
3. Roger Hunt and Ed Bausbacher, “Process Plant layout and Piping Design” PTR Prentice-Hall Inc.
4. F.C. Vibrandt and C.E. Dryden, “Chemical Engineering Plant Design”, McGraw Hill, Fifth Edition.

Course Contents and Lecture Schedule

No.	Details	No. of Lectures
1	**Module 1**	**5**
1.1	Process Utility Systems: Classification of process utility systems, Importance of process utilities in chemical industries and plants.	2
1.2	Water as a utility in process industries: Sources of water, hard and soft water, requisites of industrial water and its uses, methods of water treatment, storage and distribution of water, recycle and conservation of water.	2
1.3	Cooling Tower: Types and performance evaluation.	1
2	**Module II**	**6**
2.1	Introduction to Fuels, Properties of Fuel oil, Coal and Gas, Storage, handling and preparation of fuels, Principles of Combustion, Combustion of Oil, Coal and Gas.	2
2.2	Compressed air system: Types of air compressors, Compressor efficiency, Efficient compressor operation, Compressed air system components, Capacity assessment, Leakage test, Factors affecting the performance and efficiency of compressors.	3
2.3	Vacuum Pumps: Types of vacuum pumps and their performance characteristics.	1
3	**Module III**	**8**
3.1	Steam System: Steam and its importance, Properties of steam, Problems based on enthalpy calculation for wet steam, dry saturated steam and superheated steam.	1
3.2	Boilers: Types of steam generators/boilers, Combustion in boilers, Performance evaluation, Analysis of losses, Feed water treatment, Blow down, Energy conservation opportunities, Boilers Act.	3
3.3	Steam handling and distribution: Steam distribution system, Assessment of steam distribution losses, Steam economy, Steam traps, Condensate and flash steam recovery system, Identifying opportunities for energy savings.	2
3.4	Waste Heat Recovery: Classification, Advantages and applications, commercially viable waste heat recovery devices, Saving potential.	2

4	**Module IV**	**6**
4.1	Refrigeration and Ventilation: Principles of refrigeration, vapour compression and vapour absorption refrigeration cycles, types of refrigerants and their importance. Production of cryogenic temperatures.	3
4.2	Characteristics of Air-water systems. Humidification and Dehumidification equipments. Exhaust & Ventilation.	3
5	**Module V**	**10**
5.1	Introduction to Piping: Classification of pipes, pipe materials, pipe sizing, pipe wall thickness, schedule number, codes and standards. Piping colour codes as per types of fluid passing through pipes.	2
5.2	Piping Components: Pipes, Fittings, Flanges, Gaskets, Bolting and Valves.	1
5.3	Pipe fittings: Functions and properties, types of pipe fittings and their selection.	2
5.4	Gaskets: Functions and properties, types of gaskets and their selection.	1
5.5	Valves: Types of valves, selection criteria of valves for various systems.	2
5.6	Piping insulation: Insulation materials, estimating thickness of insulation, critical thickness of insulation, optimal thickness of insulation.	2

CHT464	DRUGS AND PHARMACEUTICALS TECHNOLOGY	CATEGORY	L	T	P	CREDIT
		PEC	2	1	0	3

Preamble: To give an insight into drug discovery and development of drugs, organic therapeutic agents uses and economics, understand different unit processes and its application, manufacturing principles and product formulation, conventional drug development process and regulatory procedures and production of selected biopharmaceutical products.

Prerequisite: Nil

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

CO 1	Explain principles of preformulations and basic formulation considerations for monophasic liquid orals and emulsions suspensions, suppositories and aerosols
CO 2	Describe preformulation, formulation and unit operation involved in the manufacturing of tablets
CO 3	Explain the coating polymers, technology and equipments used for coating of tablets and describe microencapsulation techniques
CO 4	Describe formulations for hard and soft gelatin capsules, machinery used for filling hard gelatin capsules, process for soft gelatin capsules manufacturing, evaluation of capsules
CO 5	Describe Preformulation, formulation, evaluation and large scale manufacturing, packaging of oral controlled release and sustained release 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											
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
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):

1. Explain the methods of filling of aerosol and the evaluation of aerosol system.

2. Explain the significance of preformulation studies in manufacture of suspensions

3. Explain theories of emulsification

Course Outcome 2 (CO2)

1. List out the steps involved for tablet compression

2. Classify the different types of tablets. Give an account of tablet compaction by rotary compression process.

3. What are the processing problems encountered in compression of tablets

Course Outcome 3(CO3):

1. Explain various enteric and non-enteric polymers used for tablet coating

2. Explain the steps involved in sugar coating

3. Explain the significance of microencapsulation and discuss any one microencapsulation technique

Course Outcome 4 (CO4):

1. Describe the manufacture of soft gelatin capsule by Rotary die process.

2. Discuss about the quality control test for hard gelatin capsules

3. Explain the limitation for using hard gelatin capsules

Course Outcome 5 (CO5):

1. Explain the approaches involved in design of controlled release formulations

2. Explain the concepts of drug targeting

3. Describe the manufacture of liposomes

Model Question Paper

QP CODE: **Total Pages:**

Reg No.:_______________

Name:___________________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

EIGHTH SEMESTER B. TECH DEGREE EXAMINATION, -------------

Course Code: CHT464

Course Name: DRUGS AND PHARMACEUTICALS TECHNOLOGY

Max. Marks: 100 Duration: 3 Hours

Part A

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

1. Explain the fermentation process for the production of Pencillin
2. List the properties and uses of aspirin
3. Classify different types of coating process of tablets
4. Discuss about the formulation of hard gelatin capsules
5. Explain the packaging techniques in parenterals
6. Differentiate syrups and elixirs
7. List out the manufacturing techniques of ointments
8. Explain about nano-particulate drug delivery systems
9. Explain sterility testing of drugs and pharmaceuticals
10. Explain the role of chromatographic techniques in the isolation of pharmaceutically active ingredients

(10 × 3 = 30 marks)

PART B

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

Module - I

11. Explain the different phases in drug discovery and development (14)

OR

12. Outline the synthesis, properties a, uses and testing of paracetamol and isonicotinic acid dihydrazine (14)

Module - II

13. Explain the various quality control tests for tablets (14)

OR

14. Explain microencapsulation by co-acervation phase separation (14)

Module - III

15. Explain the requirements of parenteral preparations and discuss the quality control test for parenteral products. (14)

OR

16. a Discuss about the instability of emulsions (8)
    b Explain the stabilization techniques for emulsions (6)

Module - IV

17. Explain the methods of filling of aerosol and the evaluation of aerosol system. (14)

OR

18. a Explain various suppository bases (8)
    b Explain various techniques for manufacture of suppositories (6)

Module - V

19. Explain the methods for sterilization of drugs and pharmaceuticals (14)

OR

20. Explain any three analytical methods for drug development and quality control (14)

Syllabus

Module 1 **(6 hours)**

Pharmaceutical Industry, Drug discovery and Development of Drugs, Organic Therapeutic agents uses and Economics. Chemical Conversion Processes - Alkylation, Carboxylation, Condensation, Cyclisation, Dehydration, Esterification, Halogenation Oxidation, Sulfonation, Complex Chemical Conversions and Fermentation.

Outlines of preparation, properties, uses and testing of the following pharmaceuticals and fine chemicals, sulfacetamide, paracetamol, methyl orange, riboflavin, nicotinamide, procaine hydrochloride, para-amino salicylic acid, isonicotinic acid hydrazide, aspirin, penicillin, calcium gluconate, ferric ammonium citrate

Module 2 **(8 hours)**

Compressed Tablets, Wet Granulation, Dry Granulation or Slugging, Direct Compression, Tablet Presses, Formulation,

Introduction to tablet coating: rationale, advantages etc. • Preformulation considerations for tablet coating • Types of coating • Quality control of coated and uncoated tablets

Introduction to capsule dosage form: rationale, advantages etc. Preformulation considerations for capsule dosage form. Hard gelatin capsules: formulation considerations, capsule manufacture equipments, quality control tests, packaging,

Soft gelatin capsules: formulation considerations, capsule filling equipments, quality control tests, packaging, Microencapsulation, Fabrication techniques, Evaluation

Module 3 **(9 hours)**

Monophasics (Oral and Topicals)(solution, syrups, elixirs, linctus, nasal drops, ear drops, etc.), Preformulation, Formulation, Quality Control

Biphasic - Suspensions • Preformulation • Principles and Stabilization techniques • Formulation Development • Evaluation • Large scale manufacture and packaging with focus on equipment Biphasic - Emulsions • Preformulation • Theories of emulsions • Formulation • Evaluation including stress testing • Large scale manufacture and packaging with focus one equipment

Parenteral preparations: large volume and small volume parenterals, Standard of Hygiene and Good Manufacturing Practice (GMP), Packing techniques and quality control.

Module 4 **(7 hours)**

Ointments • Preformulation • Formulation • Evaluation • Large scale manufacture and packaging with focus onequipment • Creams • Preformulation • Formulation • Evaluation • Large scale manufacture and packaging with focus onequipment Gels • Preformulation • Formulation • Evaluation • Large scale manufacture and packaging with focus onequipment • Suppositories • Preformulation • Formulation • Evaluation • Large scale manufacturing with focus onequipment • Aerosols • Containers and Propellants • Formulation of aerosols • Evaluation of aerosols

Oral sustained release and controlled release formulations • Preformulation • Formulation of matrix and reservoir type systems, Drug targeting: concepts, liposomes, nanoparticles, niosomes

Module 5 **(5 hours)**

Sterilization: Introduction, risk factor, methods of sterilization, heat (dry and moist), heating with bactericide, filtration, gaseous sterilization and radiation sterilization, suitable example to be discussed and sterilization testing.

Analytical Methods and Tests for various Drugs & Pharmaceuticals- principle, instrumentation and applications of UV/VIS and IR spectroscopy, X-ray diffraction analysis, Fourier transform spectroscopy, chromatography principle and its types, fluorimetry, polarimetry.

Text Books

1. Shayne Cox Gad. Pharmaceutical Manufacturing Handbook, Published by John Wiley and Sons, Inc., 2008.
2. Bernd Meibohm. Pharmacokinetics and Pharmacodynamics of biotech drugs, Published by Wiley-VCH, 2006.
3. Rawlines, E.A.; "Bentleys Text book of Pharmaceutics ", III Edition, Bailliere Tindall, London, 1977.

Reference Books

1. Remington-The Science and Practice of Pharmacy (Vol.1& 2),
2. Pharmaceutical Production Facilities: Design & Applications, Graham C.Cole,1st Edition , 1990, Ellis Horwood
3. Theory & Practice Of Industrial Pharmacy, Leon Lachman ,Herbert A.Lieberman& Joseph Kanig, 3rdedition, 1987, Lea &Febiger, Philadelphia
4. ICH Guidelines 7 Coated Pharmaceutical Dosage Forms, K. H. Bauer, CRC Press, Boca Raton. Med Pharm.
5. Pharmaceutical Coating Technology, G. C. Cole, New York, Ellis, Horwood, 1990
6. Pulsed and Self-Regulated Drug Delivery, J. Kost, Florida, CRC Press, 1987
7. Extended Release Dosage Forms, - KlowCzynski, Florida, CRC Press, 1987
8. Hard Capsules: Development and Technology, K. Ridgway, London Pharmaceutical Press 1987
9. Process Systems Engineering for Pharmaceutical Manufacturing Volume 41, Edited by Ravendra Singh , Zhihong Yuan Tsinghua, Elsevier, 2018
10. Pharmaceutical Suspensions from Formulation Development to Manufacturing, Edited by Alok K. Kulshreshtha, Onkar N. Singh, G. Michael Wall, Springer, 2010

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Module 1**	**6**
1.1	Pharmaceutical Industry, Drug discovery and Development of Drugs, Organic Therapeutic agents uses and Economics.	1
1.2	Chemical Conversion Processes - Alkylation, Carboxylation, Condensation, Cyclisation, Dehydration, Esterification, Halogenation Oxidation, Sulfonation, Complex Chemical Conversions and Fermentation.	2
1.3	Outlines of preparation, properties, uses and testing of the following pharmaceuticals and fine chemicals, sulfacetamide, paracetamol, methyl orange, riboflavin, nicotinamide	1
1.4	Outlines of preparation, properties, uses and testing of the following pharmaceuticals and fine chemicals, procaine hydrochloride, para-amino salicylic acid, isonicotinic acid hydrazide	1
	Outlines of preparation, properties, uses and testing of the following pharmaceuticals and fine aspirin, penicillin, calcium gluconate, ferric ammonium citrate	1
2	**Module 2**	**8**
2.1	Compressed Tablets: Formulation	1
2.2	Wet Granulation, Dry Granulation or Slugging, Direct Compression,	1
2.3	Tablet Presses, processing problems	1
2.4	Introduction to tablet coating: rationale, advantages Types of coating	1
2.5	Quality control of coated and uncoated tablets	1
	Introduction to capsule dosage form. Hard gelatin capsules: formulation considerations, capsule manufacture equipments, quality control tests, packaging,	1
	Soft gelatin capsules: formulation considerations, capsule filling equipments, quality control tests, packaging,	1
	Microencapsulation, Fabrication techniques, Evaluation	1
3	**Module 3**	**9**
3.1	Monophasic liquids: Oral and Topicals (solution, syrups, elixirs, linctus, nasal drops, ear drops, etc.), Formulation, Quality Control	1
3.2	Biphasic - Suspensions Preformulation Principles and Stabilization techniques Formulation Development	1
	Biphasic - Emulsions Preformulation Theories of emulsions Formulation	1

	Evaluation including stress testing Large scale manufacture and packaging with focus on equipment	1
3.3	Parenteral preparations: large volume and small volume parenterals,	1
	Formulation of small and large volume parenterals	1
	Standard of Hygiene and Good Manufacturing Practice (GMP),	1
	Packing techniques	1
	Quality control.	1
4	**Module 4**	**7**
4.1	Ointments Preformulation Formulation Evaluation Large scale manufacture and packaging with focus on equipment	1
	Creams Preformulation Formulation Evaluation Large scale manufacture and packaging with focus on equipment, Gels • Preformulation Formulation Evaluation Large scale manufacture and packaging with focus onequipment	1
4.2	Suppositories Preformulation Formulation Evaluation Large scale manufacturing with focus on equipment	1
4.3	Aerosols Containers and Propellants	1
4.4	Formulation of aerosols Evaluation of aerosols	1
4.5	Oral sustained release and controlled release formulations • Preformulation Formulation of matrix and reservoir type systems,	1
	Drug targeting: concepts, liposomes, nanoparticles, niosomes	1
5	**Module 5**	**5**
5.1	Sterilization: Introduction, risk factor, methods of sterilization, heat (dry and moist)	1
5.2	heating with bactericide, filtration, gaseous sterilization and radiation sterilization, suitable example to be discussed and sterilization testing.	1
5.3	Analytical Methods and Tests for various Drugs & Pharmaceuticals- principle, instrumentation and applications of UV/VIS and IR spectroscopy,	1
5.4	X-ray diffraction analysis, Fourier transform spectroscopy,	1
	chromatography principle and its types, fluorimetry, polarimetry.	1

CHT474	ELECTROCHEMICAL ENGINEERING	CATEGORY	L	T	P	CREDIT
		PEC	2	1	0	3

Preamble: This course covers the key aspects of electrochemical engineering. This course will provide knowledge about electrochemical process and its applications.

Prerequisite: Nil

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

CO 1	Understand the basics of electrochemistry and the laws associated with it.
CO 2	Describe the mass transfer phenomena in electrochemical systems.
CO 3	Understand the fundamentals of corrosion and study the theories of corrosion.
CO 4	Classify and understand the principles of electrochemical process.
CO 5	Understand the fundamentals of electrochemical reactors and its applications.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO 1	3	3	3									
CO 2	3	3	3									
CO 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	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 a maximum of two subdivisions and carry 14 marks.

Course Level Assessment Question

Course Outcome 1 (CO1): Understand the basics of electrochemistry and the laws associated with it.

1. What is polarisation and Explain in detail about active polarisation and concentration polarisation.
2. Derive the Nernst equation and explain about its applications.
3. State faraday' laws.
4. Write a note on electrical double layer (Helmoltz and Stern Model)

Course Outcome 2 (CO2): Describe the mass transfer phenomena in electrochemical systems.

1. What are thethree basic mechanisms of mass transport in electrochemical systems?
2. Explain convection with respect to electrochemical systems.
3. Write a note on boundary conditions in electrochemical problems.
4. Explain the effect of adding excess electrolyte on mass transport.

Course Outcome 3(CO3): Understand the fundamentals of corrosion and study the theories of corrosion.

1. Discuss the effects of temperature and velocity on corrosion rates?
2. Write a note on differential metal corrosion.
3. Explain waterline corrosion & pitting corrosion.
4. Explain why nut & bolt should be made up of same metal

Course Outcome 4 (CO4): Classify and understand the principles of the electrochemistry process.

1. What is electrode deposition? Explain in detail the factors affecting electrode deposition.
2. Explain the treatment methods used for surface cleaning of metals in electroplating.
3. With a neat diagram explain lead storage batteries.
4. What is electro refining? Explain with an example.

Course Outcome 5 (CO5): Understand the fundamentals of electrochemical reactors and its applications.

1. Derive the basic design equation for electrochemical CSTR.

2. Write a note on swiss roll cell.
3. Write the merits and demerits of fluidized bed electrochemical reactor.
4. Write a note on electrochemical batch cell.

Model Question Paper

QP CODE: **PAGES: 3**

Reg No: ______________

Name: ___________________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

EIGHTH SEMESTER B. TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: CHT474

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

ELECTROCHEMICAL ENGINEERING

PART – A

Answer All the Questions (10 x 3 = 30)

1. What is polarisation?
2. Write a note on the electrocapillary curve.
3. Explain the working of a rotating disc electrode.
4. What is migration? What is the contribution of migration to total flux.
5. Explain electrochemical theory of corrosion by taking Fe as an example.
6. Differentiate between wet and dry corrosion.
7. What are the limitations of electropolishing?
8. What is anodising? Give its applications.
9. List the applications of electrochemical reactors.
10. Explain the different reactor operation modes?

PART – B

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

Module 1

11. Explain Faraday's law of electrolysis with equations. Mention their applications

OR

12. Define standard electrode potential of an electrode. Define Nernst equation for a general redox reaction.

Module 2

13. Explain in detail about the different modes of mass transfer in electrochemical systems.

OR

14. Derive Nernst Planck equation for mass transport in one dimension.

Module 3

15. Explain the mechanism of corrosion in detail.

OR

16. Explain the methods used in corrosion prevention.

Module 4

17. Explain the theory of electrodeposition.

OR

18. With a neat diagram explain hydrogen oxygen fuel cell.

Module 5

19. Explain in detail on the parameters and choices regarding the design features in electrochemical flow reactors.

OR

20. Derive the basic design equation for electrochemical plug flow reactors.

Syllabus

Module 1: Review basics of electrochemistry (6 Hrs.)

Review basics of electrochemistry: Faraday's law, Nernst potential galvanic cells, polarography. The electrical double layer, its role in electrochemical processes, electro capillary curve, Helmoltz layer, Guoy, Stern layer, fields at the interface.

Module 2: Mass transfer in electrochemical systems (7 Hrs.)

Mass transfer in electrochemical systems: Diffusion controlled electrochemical reaction, importance of convention and the concept of limiting current, over potential, primary, secondary current distribution, rotating disc electrode.

Module 3: Introduction to corrosion (6 Hrs.)

Introduction to corrosion: Electrochemical series, corrosion theories- derivation of potential, current relations of activities controlled and diffusion-controlled corrosion process. Potential, pH diagram, forms of corrosion, definition, factors and control methods of various forms of corrosion.

Module 4: Classification and understanding the principles of electrochemical process (8 Hrs.)

Classification and understanding the principles of electrochemical process: Electro deposition, electro refining, electroforming, electro polishing, anodizing, selective solar coatings, primary and secondary batteries, types of batteries, fuel cells.

Module 5: Electrodes used in different electrochemical industries (8 Hrs.)

Electrodes used in different electrochemical industries: Metals-Graphite – Lead dioxide – Titanium substrate insoluble electrodes – Iron oxide – semiconducting type etc. Metal finishing- cell design. Types of electrochemical reactors, batch cell, fluidized bed electrochemical reactor, filter press cell, Swiss roll cell, plug flow cell, design equation, figures of merits of different types of electrochemical reactors.

Text Books

1. Picket, Electrochemical Engineering, Prentice Hall, 1977.

2. Newman, J.S., Electrochemical systems, Prentice Hall, 1973.

Reference Books

1. Barak, M. and Stevenge, U.K., Electrochemical Power Sources – Primary and Secondary Batteries, 1980.

2. Mantell, C., Electrochemical Engineering, McGraw Hill, 1972.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Module 1**	**6**
1.1	Faraday's law, Nernst potential galvanic cells.	2
1.2	Polarography. The electrical double layer, its role in electrochemical processes,	2
1.3	Electro capillary curve, Helmoltz layer, Guoy, Stern layer, fields at the interface.	2
2	**Module 2**	**7**
2.1	Diffusion controlled electrochemical reaction	2
2.2	Importance of convention and the concept of limiting current	2
2.3	Over potential, primary, secondary current distribution.	2
24	Rotating disc electrode.	1
3	**Module 3**	**6**
3.1	series, corrosion theories derivation of potential	1
3.2	Current relations of activities controlled and diffusion controlled corrosion process.	2
3.3	Potential, pH diagram.	1
3.4	Forms of corrosion, definition,	1
3.5	Factors and control methods of various forms of corrosion.	1
4	**Module 4**	**8**
4.1	Electro deposition, electro refining.	2
4.2	Electroforming, electro polishing, anodizing	2
4.3	Selective solar coatings, primary and secondary batteries, types of batteries.	2
4.4	Fuel cells.	2
5	**Module 5**	**8**
5.1	Electrodes used in different electrochemical industries: Metals-Graphite – Lead dioxide – Titanium substrate insoluble electrodes – Iron oxide – semi conducting type etc.	2
5.2	Metal finishing- cell design.	1
5.3	Types of electrochemical reactors, batch cell, fluidized bed electrochemical reactor,	2
5.4	filter press cell, Swiss roll cell, plug flow cell,	1
5.5	Design equation, figures of merits of different type of electrochemical reactors.	2

SEMESTER VIII

PROGRAM ELECTIVE IV

CHT416	ECONOMICS AND MANAGEMENT OF CHEMICAL INDUSTRIES	CATEGORY	L	T	P	CREDIT
		PEC	2	1	0	3

Preamble: The economics and management of chemical industries is one of the key areas where Chemical Engineer needs focus. This course focuses on economic and cost analysis of engineering projects, giving insights on tools used for cost estimation, profitability analysis and taking decision among alternatives. The basic purpose of this course is to provide a sound understanding of concepts and principles of engineering economy and to develop proficiency with methods for making rational decisions regarding problems likely to be encountered in professional practice.

Prerequisite: Nil

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

CO 1	Apply the concept of time value of money, unacost, capitalized cost etc. for comparing projects of equal and unequal duration
CO 2	Understand the concept of depreciation and apply different methods for calculating depreciation in real life projects.
CO 3	Apply different techniques and tools for cost estimation of the projects
CO 4	Utilize different methods for calculating profitability for project selection and ranking
CO 5	Apply the concept of break even analysis for selecting / designing a project
CO 6	Understand the principle of accounting, prepare financial statements and analyse the financial status of the company

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										
CO 3	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	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): Apply the concept of time value of money, unacost, capitalized cost etc. for comparing projects of equal and unequal duration

1. Differentiate between simple interest and compound interest
2. Calculate the effective interest rate if compounding is done quarterly at a rate of 7.2%
3. A heat exchanger costs Rs.1, 25,000 and salvage value is 5,000 after 9 years. Operating cost is 10,000. A similar heat exchanger cost 2, 30,000 with an annual operating cost of 25,000 and salvage value of 20,000 lasts 15 years. Which one is economical?

Course Outcome 2 (CO2): Understand the concept of depreciation and apply different methods for calculating depreciation in real life projects.

1. What is depreciation and what is its significance? Explain any two methods for calculating depreciation

2. An asset of Rs 200,000 has a salvage value of 1000 after a service life of 8years. Find the annual depreciation, book value at the end of 3rd and 5th yearusing a) straight line method b) declining balance method c) sum of years digit method
3. Discuss the declining balance and sinking fund methods for calculating depreciation?

Course Outcome 3(CO3): Apply different techniques and tools for cost estimation of the projects.

1. Discuss the cost indices used in cost estimation
2. Explain order of magnitude and study estimates for cost estimation
3. What are the different types of techniques used for cost estimation

Course Outcome 4 (CO4): Utilize different methods for calculating profitability for project selection and ranking

1. What is DCFRR? What are the advantage of using DCFRR for profitability analysis
2. What is NPV? Discuss its advantages and disadvantages
3. Discuss the mathematical criteria used for profitability analysis

Course Outcome 5 (CO5): Apply the concept of break even analysis for selecting / designing a project.

1. What is Break even analysis? Discuss different factors required for doing this analysis
2. Discuss the economic production charts for 100 % capacity with diagram. State the assumptions clearly
3. If price/unit in Rs. is (1000-D/5), where D is the annual demand, the total cost per year can be approximated as (1000+2D2). Determine the value of D that maximises the profit

Course Outcome 6 (CO6): Understand the principle of accounting, prepare financial statements and analyse the financial status of the company

1. What is meant by trial balance?
2. Discuss any five ratios used for the analysis of balance sheets
3. Explain the process of finding gross profit and net profit from profit and loss account

Model Question Paper

QP CODE: **PAGES: 3**

Reg No: ______________

Name: ___________________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

EIGHTH SEMESTER B. TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: CHT416

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

ECONOMICS AND MANAGEMENT OF CHEMICAL INDUSTRIES

PART – A

Answer All the Questions (10 x 3 = 30)

1. What is effective interest rate? Obtain the relation between effective interest rate and nominal interest rate.
2. Discuss the effect of depreciation on tax.
3. Write a note on order of magnitude estimate for cost estimation.
4. What is meant by cost index? What is the use of it in cost estimation
5. What is DCFRR? Explain the method of calculation with a suitable example
6. What is NPV?
7. What is meant by break even analysis? What is the significance of breakeven point?
8. Discuss the assumptions made in preparing economic production charts? Discuss its effects
9. What is book keeping? Discuss the stages of book keeping and the concept of double entry system
10. Write any three ratios used for analysis of balance sheet

PART – B

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

Module 1

11. (a) Two pipes are available for carrying water with costs as follows

	A	B
First cost, Rs	5,00,000	9,00,000
Annual end of year cost, Rs/Year	1,00,000	90,000
Salvage value, Rs	0	0
Life, Yrs	10	15

Type A must be repaired at times and water can get contaminated at this time. Type B contamination is negligible. If money is worth 6% per year, how much benefit must be given to type B to make it economically equal to A. (10 marks)

(b) Explain the sinking fund methods of calculating depreciation (4 marks)

OR

12. An asset of Rs 500,000 has a salvage value of Rs 2000 after a service life of 5 years. Find the annual depreciation and present value of the depreciation for the following methods) Straight line method b) declining balance method c) sum of years digit method (14 marks)

Module 2

13. a)An ethylene plant with a capacity of 1,00,000 t/year costs 16 M$. Estimate the cost of a 2,00,000 t/year plant using William's six-tenth factor rule method (5 marks)

b) An air-conditioning system was purchased in 1983 for $ 1,60,000. Estimates its cost in 1989 using both Marshall & Swift Index and Chemical Engineering Plant Cost Index. (M&S Index: 1983 –761, 1989 – 857; Chemical Engineering Plant Cost Index: 1983 –317, 1989 – 345) (9 marks)

OR

14. Discuss different methods of cost estimation (14 marks)

Module 3

15. What are the different mathematical methods used for which profitability evaluation? Explain briefly (14 marks)

OR

16. A company has two proposals A and B which would require an initial investment of Rs. 24,000 and Rs. 21312 respectively. The cash flows of the two proposals are

Year	1	2	3	4
Proposals 'A' (Rs.)	20,000	2,000	2,000	4,000
Proposals 'B'(Rs.)	4,000	2,000	2,000	19,000

Which of those proposals should be selected following DCFRR method? (14 marks)

Module 4

17. a) If price/unit in Rs. is (1000-D/5), where D is the annual demand, the total cost per year can be approximated as (1000+2D2). Determine the value of D that maximises the profit (7 marks)

b) Discuss the use of economic production chart for break even analysis. Draw a neat diagram of economic production chart for 100% capacity and explain? (7 marks)

OR

18. For net sales of a company amounting to Rs 6,00,000 annually, when the fixed costs are Rs 3,50,000 and the direct costs are 35 percent of the net sales i) What is the gross profit?ii) What is the breakeven point?iii) What sales are required to make a profit of Rs.80,000?

(14 marks)

Module 5

19. The balance sheet of a company gives the following details. Prepare the balance sheet.

Workout economics and comment on the financial stability of company

Current assets	400 lakhs
Current liabilities	85 lakhs
Stocks and shares	600 lakhs
Quick assets	225 lakhs
Surplus	715 lakhs

(14 marks)

OR

20. Prepare Trading, profit & Loss account and balance sheet from the following details

Debit balances (in Rs)

Furniture-6400, Vehicles-62500, Buildings-75900, Bad debts-1250, sundry debtors-38000, Stock on 1st April 2005-34600, Purchases-55750, sales retrn-2000, Advertising-4500, Interest-1180, cash in hand-6500, Taxes and insurance- 12500, General charges- 7820, salaries- 33000

Credit balances (in Rs)

Capital- 128900, bills payable- 2000, sundry debtors- 25000, sales- 154500, Bank overdraft- 28500, purchase returns- 1250, commission-1750

The value of stock on 31st March 2006 was Rs. 32500 (14 marks)

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Syllabus

Module 1: Equivalence and cost comparisons (8 Hrs.)

Equivalence and cost comparisons:- Time value of money and equivalence, equations used in economic analysis, compound interest and continuous interest, unacost, capitalized cost, cost comparison with equal and unequal duration of service life, depreciation and taxes, nature of depreciation , methods of determining depreciation, straight line, declining balances, double-declining balance, sum of years digits, sinking fund and units of production methods

Module 2: Cost estimation (7 Hrs.)

Cost Estimation: Cost indices, material cost indices, labour cost indices, William's six tenth factor, location index, types of cost estimates:- order of magnitude estimate, study estimate, preliminary estimate, definitive estimate, detailed estimate, techniques of cost estimates: - conference techniques, comparison techniques graphic relationship, tabular relationship, unit rate techniques, lang factor method, hand factor method, Chilton method, miller method, Peter's and Timmerhaus ratio factor method, Items for capital cost estimates, product cost estimates, direct production cost, administration expenses, items for total product cost estimates, elements of complete costs, start up costs

Module 3: Profitability analysis (6 Hrs.)

Profitability analysis, mathematical methods for profitability evaluation, payout time, payout time with interest, return on average investment, Return on original investment, net present value, net present value index, DCF rate of return, incremental analysis.

Module 4: Breakeven and minimum cost analysis (6 Hrs.)

Breakeven and minimum cost analysis, variable cost and fixed cost, Break even analysis, economic production chart for 100% capacity, above 100% capacity and dumping, non-linear economic production chart, Inflation, unaburden.

Module 5: Principles of accounting (8 Hrs.)

Principles of accounting, accounting definition, trial balance, profit and loss accounts, balance sheet , financial ratios related to balance sheet and profit and loss account, canons of ethics of engineers.

Text Books

1. Jelen F.C., Cost and Optimisation Engineering, McGraw Hill
2. Peters &Timmerhaus, Plant Design & Economics for Chemical Engineering, McGraw Hill

Reference Books

1. Davies G.S., Process Engineering Economics, Chem. Eng. Ed. Dev. Centre, IIT Madras
2. Schweyer, Process Engineering Economics, McGraw Hill
3. Tyler, Chemical Engineering Cost Estimation
4. Aries & Newton, Chemical Engineering & Cost Estimation
5. Happel, Chemical Process Economics, Marcel Decker

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Module-1**	**8**
1.1	Time value of money and equivalence	1
1.2	Equations used in economic analysis , compound interest and continuous interest	1
1.3	Unacost, capitalized cost	1
1.4	Cost comparison with equal and unequal duration of service life	2
1.5	Depreciation and taxes , nature of depreciation	1
1.6	Methods of determining depreciation , straight line , declining balances , double declining balance	1
1.7	sum of years digits, sinking fund and units of production methods	1
2	**Module-2**	**7**
2.1	Cost indices , material cost indices, labour cost indices , William's six tenth factor , location index	2
2.2	Types of cost estimates:- order of magnitude estimate , study estimate , preliminary estimate , definitive estimate , detailed estimate	1
2.3	Techniques of cost estimates:- conference techniques , comparison techniques graphic relationship , tabular relationship , unit rate techniques , lang factor method , hand factor method , Chilton method , miller method , Peter's and Timmerhaus ratio factor method	2
2.4	Items for capital cost estimates, product cost estimates, direct production cost, administration expenses -	1
2.5	Items for total product cost estimates - elements of complete costs - start up costs	1
3	**Module-3**	**6**
3.1	Mathematical methods for profitability evaluation , payout time , payout time with interest	2
3.2	Return on average investment ,Return on original investment	1
3.3	Net present value , net present value index	1
3.4	DCF rate of return	1
3.5	Incremental analysis	1
4	**Module-4**	**6**
4.1	Variable cost and fixed cost	1

4.2	Break even analysis	1
4.3	Economic production chart for 100% capacity, above 100% capacity and dumping	2
4.4	Non-linear economic production chart	1
4.5	Inflation, unaburden	1
5	**Module-5**	**8**
5.1	Accounting definition , trial balance	2
5.2	Profit and loss accounts	2
5.3	Balance sheet	2
5.4	Financial ratios related to balance sheet and profit and loss account	1
5.5	canons of ethics of engineers	1

CHT426	PETROCHEMICALS AND FERTILIZERS	CATEGORY	L	T	P	CREDIT
		PEC	2	1	0	3

Preamble: The scope for Petrochemical Engineers is tending to grow in future due to industry expansion and the related scarcity of resources needed. The various chapters of petrochemical technology like C1, C2, C3, C4 fractions and Aromatics etc, provide the complete sketch about the processes in all petrochemical complexes, also provides the processing of raw materials for various commercial products based on crude petroleum. Indian economy is dominated by agriculture sector. It is therefore vital for chemical engineers to understand for each fertilizer product, its flow diagram for industry production. For this purpose, students should have skills for arranging treatment, reaction and separation steps in a flow diagram for variety of fertilizers including Nitrogenous, Phosphatic, Potash and Bio fertilizers is essential. This course is designed to achieve these objectives.

Prerequisite: Nil

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

CO 1	Describe the manufacturing process for C1 and C2 compounds.
CO 2	Describe the manufacturing process for C3 and C4 compounds.
CO 3	Explain the manufacturing process for Aromatic Compounds and characterize fertilizers on the basis of different properties.
CO 4	Describe the relevant manufacturing process for Nitrogenous fertilizers.
CO 5	Explain the relevant manufacturing process for potassic and miscellaneous fertilizers.

Mapping of course outcomes with program outcomes

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**
CO 1	3	3	2							2		
CO 2	3	3	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	40
Apply	20	20	50
Analyse			

Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

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

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, 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): Describe the manufacturing process for C1 and C2 compounds

1. List three petrochemical products and their applications.
2. Write any three industrial uses of ethylene.
3. List the physical properties and uses of Vinyl Chloride. Explain the production of Vinyl Chloride by ethylene dichloride pyrolysis with a flow diagram.
4. Explain the manufacture of Chloromethane by direct chlorination of methane using a flow diagram. List the engineering problems involved

Course Outcome 2 (CO2): Describe the manufacturing process for C3 and C4 compounds

1. List the processes and raw materials available for the production of Butadiene.
2. Write the steps involved in the production of acrylonitrile.
3. Explain the manufacturing process of acetone from isopropanol with a flow diagram.
4. List the physical properties and uses of Butadiene. Describe the manufacture of Butadiene by steam cracking of hydrocarbons with a flow diagram.

Course Outcome 3(CO3): Explain the manufacturing process for Aromatic Compounds and characterize fertilizers on the basis of different properties.

1. List the physical properties and uses of Styrene.
2. Write the reactions involved in the productions of Phthalic anhydride by Oxidation of Naphthalene
3. Explain the commercial production of Phenol by Cumene process using a flowchart. List the major engineering problems involved.
4. a) Write note on application of fertilizers considering nutrient balance and type of crops. Describe the role of essential elements in plant growth.

   b) Write a note on fertilizer production and consumption in India.

Course Outcome 4 (CO4): Describe the relevant manufacturing process for Nitrogeneous fertilizers.

1. Write the reactions involved in the manufacture of ammonium chloride.
2. List the properties and applications of Nitric Acid.
3. Draw a process flow diagram and explain the manufacture of Urea by Stamicarbon's CO_2 stripping process.
4. Describe manufacturing of Nitric acid by pressure ammonia oxidation process using a flow diagram.

Course Outcome 5 (CO5): Explain the relevant manufacturing process for potassic and miscellaneous fertilizers

1. Describe Prilling process.
2. Classify fertilizers
3. List the chemical properties and uses of Potassium chloride. Explain the manufacture of potassium chloride from sylvinite with a process flow diagram
4. Explain the manufacturing of Ammonium Sulphate Phosphate (ASP) and Calcium Ammonium Nitrate (CAN) with process flow diagrams.

Model Question Paper

QP CODE: **PAGES: 3**

Reg No: ______________
Name: ___________________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
EIGHTH SEMESTER B. TECH DEGREE EXAMINATION, MONTH & YEAR
Course Code: CHT426

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

PETROCHEMICALS AND FERTILIZERS

PART – A

Answer All the Questions (10 x 3 = 30)

1. List three petrochemical products and their applications.
2. Write any three industrial uses of ethylene.
3. List the processes and raw materials available for the production of Butadiene.
4. Write the steps involved in the production of acrylonitrile.
5. List the physical properties and uses of Styrene.
6. Write the reactions involved in the productions of Phthalic anhydride by Oxidation of Naphthalene.
7. Write the reactions involved in the manufacture of ammonium chloride.
8. List the properties and applications of Nitric acid.
9. Describe Prilling process.
10. Classify fertilizers

PART – B

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

Module 1

11. List the physical properties and uses of Vinyl Chloride. Explain the production of Vinyl Chloride by ethylene dichloride pyrolysis with a flow diagram.

OR

12. Explain the manufacture of Chloromethane by direct chlorination of methane using a flow diagram. List the engineering problems involved.

Module 2

13. Explain the manufacturing process of acetone from isopropanol with a flow diagram.

OR

14. List the physical properties and uses of Butadiene. Describe the manufacture of Butadiene by steam cracking of hydrocarbons with a flow diagram.

Module 3

15. Explain the commercial production of Phenol by Cumene process using a flowchart. List the major engineering problems involved.

OR

16. a) Write note on application of fertilizers considering nutrient balance and type of crops. Describe the role of essential elements in plant growth.

b) Write a note on fertilizer production and consumption in India.

Module 4

17. Draw a process flow diagram and explain the manufacture of Urea by Stamicarbon's CO_2 stripping process.

OR

18. Describe manufacturing of Nitric acid by pressure ammonia oxidation process using a flow diagram.

Module 5

19. List the chemical properties and uses of Potassium chloride. Explain the manufacture of potassium chloride from sylvinite with a process flow diagram

OR

20. Explain the manufacturing of Ammonium Sulphate Phosphate (ASP) and Calcium Ammonium Nitrate (CAN) with process flow diagrams.

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Syllabus

Module 1: C1 and C2 Compounds **(7 Hrs.)**

C1 Compounds: Process Description, flow diagram, Physical Properties and uses of -Methanol via synthesis gas route, Formaldehyde from methanol, Chloromethane by direct chlorination of methane, Trichloroethylene, Perchloroethyene by Pyrolysis of carbon tetrachloride. C2 Compounds: Process Description, flow diagram, Physical Properties and uses of -Ethylene and acetylene Production by steam cracking of hydrocarbons, Ethylene dichloride, Vinyl Chloride via ethylene dichloride pyrolysis, Ethylene oxide by oxidation of ethylene, Ethanol amines from ethylene oxide and Ammonia.

Module 2: C3 and C4 Compounds **(6 Hrs.)**

C3 Compounds: Process Description, flow diagram, Physical Properties and uses of -Isopropanol by hydration of propylene, Acetone by dehydrogenation of Isopropanol, Acrylonitrile from Propylene Ammonia Oxidation, Isoprene from propylene dimmer, Propylene Oxide via Chlorohydrins. C4 Compounds: Process Description, flow diagram, Physical Properties and uses of -Butadiene from Dehydrogenation of butane, Butadiene by Oxydehydrogenation, Butadiene from ethanol, Butadiene from steam cracking f hydrocarbons.

Module 3: Aromatics and Overview of Fertilizer **(8 Hrs.)**

Aromatics: Process Description, flow diagram, Physical Properties and uses of –Benzene from Alkyl Aromatics, Phenol by Cumene Process, Phenol from toluene Oxidation, Styrene from benzene and ethylene, Phthalic anhydride by Oxidation of Naphthalene.

Overview of Fertilizer: Synthetic fertilizers, Classification of fertilizers, Role of essential Elements in plant Growth, Macro elements and Micro elements, Application of fertilizers considering Nutrient, Balance and types of crop. Development of fertilizer industry; Fertilizer production and consumption in India; Nutrient contents of fertilizers; Secondary nutrients; Feedstock and raw materials for nitrogenous, phosphatic and potassic fertilizers.

Module 4: Nitrogenous Fertilizers **(8 Hrs.)**

Nitrogenous Fertilizers: Introduction to Nitric acid: Chemical, physical properties and applications, Manufacturing of Nitric Acid by Pressure ammonia oxidation process and Intermediate pressure ammonia oxidation process, Urea: Physical, chemical properties, Manufacturing of Urea by Stamicarbon's CO_2 stripping process, Toyo-Koatsu total recycle process, Manufacturing of

Ammonium nitrate by Prilling process, Ammonium sulphate from Ammonium carbonate and gypsum, Ammonium chloride from Ammonium sulphate and sodium chloride.

Module 5: Potassium Fertilizers and Miscellaneous Fertilizer (6 Hrs.)

Potassium Fertilizers and Miscellaneous Fertilizers: Potassium Fertilizers: Physical, chemical properties and uses of Potassium Chloride, Potassium nitrate, Potassium sulphate, Manufacturing of potassium chloride from sylvinite, Preparation of Potassium nitrate, Potassium sulphate. Manufacturing of NPK, Ammonium Sulphate Phosphate (ASP), Calcium Ammonium Nitrate (CAN).

Text Books

1. G H Collings, Commercial Fertiliser, 5th Edition, MCGraw Hill, New York, 1955.
2. Slacks, A.V., Chemistry & Technology of Fertilizers, Interscience, New York, 1966.
3. Kirk-Othmer, Encyclopedia of Chemical Technology, 4th Edition, 1993, Wiley – Inter Science Publication, John Wiley & Sons, New York.

Reference Books

1. Editorial Board-Hand book Fertilizer Technology, The Fertiliser Association of India, New Delhi, 1998.
2. M. Gopala Rao & Marshall Sittig, Dryden's Outlines of Chemical Technology, East-West Press, 3rd Edition, New Delhi.
3. Austin G. T, Shreve's Chemical Process Industries, 5th edition, Mc. Graw Hill Publications.
4. Pandey & Shukla, Chemical Technology, Volume I & II, 2nd Edition, Vani Books Company.
5. N S Subba Rao, Bio fertilizers in Agriculture, Oxford & IBH Publishing Company.
6. Dr. B.K.Bhaskararao "A Text on Petro Chemicals" 1st Edition, Khanna Publishers.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**C1 and C2 Compounds**	**7**
1.1	Methanol via synthesis gas route, Formaldehyde from methanol, Chloromethane by direct chlorination of methane	2
1.2	Trichloroethylene Perchloroethyene by Pyrolysis of carbon tetrachloride.	1
1.3	Process Description, flow diagram, Physical Properties and uses of - Ethylene and acetylene Production by steam cracking of hydrocarbons.	2
1.4	Ethylene dichloride, Vinyl Chloride Via ethylene dichloride pyrolysis, Ethylene oxide by oxidation of ethylene, Ethanol amines from ethylene oxide and Ammonia.	2
2	**C3 and C4 Compounds**	**6**
2.1	Isopropanol by hydration of propylene, Acetone by dehydrogenation of Isopropanol.	2
2.2	Process Description, flow diagram, Physical Properties and uses of - Butadiene from Dehydrogenation of butane, Butadiene by Oxydehydrogenation,	2
2.3	Butadiene from ethanol, Butadiene from steam cracking f hydrocarbons.	2
3	**Aromatics and Overview of Fertilizer (8 Hrs)**	**8**
3.1	Benzene from Alkyl Aromatics, Phenol by Cumene Process, Phenol from toluene Oxidation.	1
3.2	Styrene from benzene and ethylene, Phthalic anhydride by Oxidation of Naphthalene.	2
3.3	Synthetic fertilizers, Classification of fertilizers	1
3.4	Role of essential Elements in plant Growth, Macro elements and Micro elements, Application of fertilizers considering Nutrient, Balance and types of crop.	1
3.5	Development of fertilizer industry; Fertilizer production and consumption in India;	1
3.6	Nutrient contents of fertilizers; Secondary nutrients; Feedstock and raw materials for nitrogenous, phosphatic and potassic fertilizers.	2
4	**Nitrogenous Fertilizers**	**8**
4.1	**Introduction to Nitric acid**: Chemical, physical properties and applications, Manufacturing of Nitric Acid by Pressure ammonia oxidation process and Intermediate pressure ammonia oxidation process,	3
4.2	**Urea**: Physical, chemical properties, Manufacturing of Urea by Stamicarbon's CO_2 stripping process, Toyo-Koatsu total recycle process	2
4.3	Manufacturing of Ammonium nitrate by Prilling process, Ammonium sulphate from Ammonium carbonate and gypsum, Ammonium chloride from Ammonium sulphate and sodium chloride.	3
5	**Potassium Fertilizers and Miscellaneous Fertilizer**	**6**

5.1	**Potassium Fertilizers**: Physical, chemical properties and uses of Potassium Chloride, Potassium nitrate, Potassium sulphate	2
5.2	Manufacturing of potassium chloride from sylvinite, Preparation of Potassium nitrate, and Potassium sulphate.	2
5.3	Manufacturing of NPK, Ammonium Sulphate Phosphate (ASP), Calcium Ammonium Nitrate (CAN).	2

CHT436	MATHEMATICAL METHODS IN PROCESS ENGINEERING	CATEGORY	L	T	P	CREDIT
		PEC	2	1	0	3

Preamble: Mathematical methods in process engineering builds on students' knowledge of calculus, linear algebra, and differential equations, employing appropriate examples and applications from chemical engineering to illustrate the techniques.

Prerequisite: Nil

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

CO1	Explain the behaviour of chemical engineering system from model equations.
CO2	Make use of concepts of linear algebra to solve chemical engineering problems.
CO3	Apply differential calculus to solve chemical engineering problems.
CO4	Develop an understanding of infinite dimensional spaces to analyze engineering problems.
CO5	Illustrate the solution methods for solving linear and nonlinear systems steady and dynamic systems.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3										
CO2	3	3										
CO3	3	3										
CO4	3	3										
CO5	3	3										

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	Test 1	Test 2	
Remember	10	10	10
Understand	20	20	30
Apply	20	20	60
Analyse			
Evaluate			
Create			

Course Level Assessment Questions

Course Outcome 1 (CO1): Explain the behaviour of chemical engineering system from model equations.

1. Classify the following equations as parabolic, elliptic or hyperbolic
$$\frac{\partial u}{\partial t} = \frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2}$$
2. The transient response to a system is given by the equation $\frac{dx}{dt} = k\sin(\omega t) - x$
   Classify this equation as linear/nonlinear, homogeneous/nonhomogeneous
3. An immersion heater generates q watts and is immersed in an insulated bucket containing V litres of well-stirred water. Obtain the equation determining the evolution of temperature in the bucket. Classify this equation as linear/nonlinear, homogeneous /nonhomogeneous

Course Outcome 2 (CO2): Make use of concepts of linear algebra to solve chemical engineering problems.

1. Explain Sturm-Louiville theory
2. Show that the eigen vectors of the matrix A are orthogonal to each other
$$\begin{bmatrix} 3 & -1 & 0 \\ -1 & 2 & -1 \\ 0 & -1 & 3 \end{bmatrix}$$
3. Discuss about the physical significance of Green's function

Course Outcome 3 (CO3): Apply differential calculus to solve chemical engineering problems.

1. Consider a two-dimensional flow field. Here the stream function ψ is defined to satisfy the equation of continuity. Write down the governing equations for ψ in an irrotational flow field
2. A tank contains 100 ft^3 of fresh water; 2 ft^3 of brine, having a concentration of 1 pcf of salt, is run into the tank per minute, and the mixture, kept uniform by mixing, runs out at the rate of 1 ft^3/min. What will be the exit brine concentration when the tank contains 150 ft^3 of brine?
3. A continuously stirred tank reactor is cooled by circulating cold water at $T_{c,in}$ through the cooling coil. The energy balance equations modelling the system are:

$$\frac{dT}{dt} = \frac{q}{V}(T_{in} - T) - \frac{UA}{V\rho C_p}(T - T_c)$$

$$\frac{dT_c}{dt} = \frac{q_c}{V_c}(T_{Cin} - T_c) - \frac{UA}{V_c\rho_c C_{pc}}(T - T_c)$$

Determine the steady state of the above system when it is modelled by,

$$\frac{dx_1}{dt} = -2x_1 + x_2 + 1$$

$$\frac{dx_2}{dt} = x_1 - (1+\alpha)x_2 + 2$$

where α=3

Course Outcome 4 (CO4): Develop an understanding of infinite dimensional spaces to analyze engineering problems.

1. Discuss the boundary conditions at the following surfaces (a) The surface is insulated (b) Steam at atmospheric pressure is condensing on the surface
2. Apply linearity and superposition to solve
$$\frac{\partial T}{\partial t} = \frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2}, 0 < x < 1, 0 < y < 1, t > 0$$
3. Write a computer code to determine the determinant of a general n x n matrix

Course Outcome 5 (CO5): Illustrate the solution methods for solving linear and nonlinear systems steady and dynamic systems.

1. Consider an isothermal first order reaction in a catalyst pellet. Model the pellet as a rectangular slab. Prove that the concentration in the slab. Prove that the concentration in the slab cannot be negative when the mass transfer coefficient at slab surface is high.
2. Consider the equation $u''(x) = \sin(\pi x)\sin(2\pi x)$ subject to $u(0) = 0, u'(0) = u'(1)$. Does this equation have a unique solution? Use: (a) maximum principles (b) energy methods
3. Apply the uniqueness criterion to the zeroth order exothermic reaction in a catalytic pellet. Assuming Dirichlet conditions, the temperature is governed by an equation of the form $\nabla^2 T + \delta e^{-\gamma/T} = 0 \; in \; V$ subject to $T=T_{in}$ on S, where δ represents a dimensionless heat of reaction, γ the dimensional activation energy, and T the dimensional temperature.

Model Question Paper

Total Pages:

Reg No.:_______________

Name:__________________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

EIGHTH SEMESTER B. TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: CHT436

Course Name: MATHEMATICAL METHODS IN PROCESS ENGINEERING

Max. Marks: 100 Duration: 3 Hours

PART A

Marks

(Answer all questions; each question carries 3 marks)

1	Distinguish between finite and infinite dimensional spaces	3
2	State the axioms to be satisfied by metric of a vector	3
3	Are the following sets of vectors from a basis for R^3. Justify $[1\ 0\ 1]^t$, $[2\ 1\ -1]^t$, [3 2 1]t, $[5\ 9\ 10]^t$	3
4	Classify the following equations as parabolic, elliptic or hyperbolic (a) $\frac{\partial u}{\partial t} = \frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2}$ (b) $\frac{\partial u}{\partial x} + \frac{\partial^2 u}{\partial x \partial y} + \frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial z^2} + \frac{\partial u}{\partial y} = 0$	3
5	Explain Sturm-Louiville theory	3
6	Discuss about the physical significance of Green's function	3
7	Discuss the direction of fluid flow (laminar) between two horizontal plates when the pressure decreases with z. The governing equation is given by $$\frac{\partial^2 v_z}{\partial y^2} = \frac{\rho}{\mu}\frac{\partial p}{\partial z}$$	3
8	Classify the steady states of a two-dimensional systems in terms of its eigen values	3
9	Explain maximum principles for uniqueness conditions	3
10	Explain homotopy continuation method?	3

PART B

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

Module -1

11 Consider a well-stirred continuous reactor sustaining the elementary reactions 14

$$A \overset{k1}{\rightarrow} 2B \overset{k2}{\rightarrow} C + D$$

Feed to the reactor is pure A at a concentration of C_{A0}. Write down the equations that describe the evolution of the concentrations of A, B, C when the residence time of the reactor is τ.

OR

12 An immersion heater generates q watts and is immersed in an insulated bucket containing V litres of well-stirred water. Obtain the equation determining the evolution of temperature in the bucket. 14

Classify this equation as linear/nonlinear, homogeneous /nonhomogeneous

Module -2

13 Determine the eigen values and eigen vectors of A 14

$$A = \begin{bmatrix} 2 & 2 & -6 \\ 2 & -1 & -3 \\ -2 & -1 & 1 \end{bmatrix}$$

OR

14 For 14

$$A = \begin{bmatrix} 2 & 1 & -3 \\ 1 & -3 & 2 \\ -3 & 2 & 1 \end{bmatrix}$$

(a) Determine whether $Au = (2, 4, 7)^t$ has a solution

(b) for what 'a', does $Au = (2, a, 8)^t$ possess a solution

Module -3

15 A continuously stirred tank reactor is cooled by circulating cold water at $T_{c,in}$ through the cooling coil. The energy balance equations modelling the system are:

$$\frac{dT}{dt} = \frac{q}{V}(T_{in} - T) - \frac{UA}{V\rho C_p}(T - T_c)$$

$$\frac{dT_c}{dt} = \frac{q_c}{V_c}(T_{Cin} - T_c) - \frac{UA}{V_c \rho_c C_{pc}}(T - T_c)$$

Determine the steady state of the above system when it is modelled by,

$$\frac{dx_1}{dt} = -2x_1 + x_2 + 1$$

$$\frac{dx_2}{dt} = x_1 - (1 + \alpha)x_2 + 2$$

where α=3

OR

16 Consider the system, 14

$$x = \dot{A}x + b$$

with $A = \begin{bmatrix} -2 & 0 \\ 1 & -3 \end{bmatrix}, b = \begin{bmatrix} 1 \\ \alpha \end{bmatrix}$

Obtain the steady state of the system for a=2, α=3. Determine the response of the system when α is changed to 4. Is this overdamped or underdamped

Module -4

17 Consider 14

$$Lu = d^2u/dx^2 - du/dx, u(0) = 0, u(1) = 0$$

Find the eigen functions of L

Find eigen functions of L^*

Convert to self-adjoint form and find eigen functions of L

OR

18 Find the adjoint operator and boundary conditions for 14

$$Lu = d^2u/dx^2 + du/dx, u(0) = 2u'(1), u(1) = 0$$

Module -5

19 Consider the equation $u''(x) = \sin(\pi x)\sin(2\pi x)$ 14

subject to $u(0) = 0, u'(0) = u'(1)$

Does this equation have a unique solution?

Use: (a) maximum principles (b) energy methods

OR

20 Enzyme catalysed and fermentation processes are usually governed by Monod kinetics. They are also carried out isothermally. Consider the reaction

$$S \rightarrow P$$

in a CSTR, where the rate expression is,

$$-r_A = \frac{\mu S}{K_1 + S}$$

Plot the bifurcation diagram depicting dependence of S on residence time for a fixed μ, K_1. Assume the feed concentration to be S_f

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Syllabus

Module 1 **(7 Hrs.)**

Introduction to: Modelling, types of modelling, simulation and types of simulation, linear and non-linear equations, homogeneous and heterogeneous equations, mathematical methods: Numerical and analytical methods, examples for modelling equations in chemical engineering for: linear and nonlinear - algebraic, ordinary differential equation and partial differential equation.

Module 2 **(7 Hrs.)**

Vectors, vector spaces, Metrics, Norms, Inner products, Linear dependence and dimension. Gram-Schmidt Orthonormalisation. Matrices, Eigen values, Eigen vectors, Fredholm alternative. Applications to Chemical Engineering: Linear algebraic equations.

Module 3 **(7 Hrs.)**

Applications to Chemical Engineering: Systems of first order homogeneous Ordinary Differential Equations (ODE) (IVP). First order non homogeneous ODE (IVP). Partial differential Equations: Classification of Second order partial differential equations. Linearity and superposition. Sturm-Louiville Theory.

Module 4 **(7 Hrs.)**

Infinite dimensional spaces, Eigen value problems, Classical Eigen value problems, Fourier Series, Rayleigh's Quotient. Separation of variables and Fourier Transforms: Rectangular Cartesian Coordinates. Cylindrical coordinates, Spherical coordinates, Fourier series and finite Fourier Transforms. Laplace Transform. Green's Function: Ordinary Differential Equations.

Module 5 **(7 Hrs.)**

Uniqueness conditions for Linear and Nonlinear Systems. Maximum principle, Energy methods, Fredholm alternative, Monotone iteration method. Steady-state Characteristics of Nonlinear Dynamical Systems: Dynamic systems, Steady-state, Continuation methods.

Text books

1. S. Pushpavanam, Mathematical Methods in Chemical Engineering, PHI
2. Jenson, V.J. and Jeffereys, G.V., Mathematical Methods in Chemical Engineering, Academic
3. Press, London and New York, 1977.
4. Mickley, H.S., Thomas. K. Sherwood and Road, C.E., Applied Mathematics in Chemical Engineering, Tata McGraw-Hill Publications, 1957.
5. Aravind Varma, M, Mordbidelli, Mathematical methods in Chemical Engineering, Oxford University Press, Indian Edition

References

1. Irvin Kreyszig, "Advanced Engineering Mathematics", New Age International (Pvt) Ltd., New Delhi

Course Contents and Lecture Schedule

No.	Topic	No. of Lectures
1.	**Module 1**	**7**
1.1	Introduction to: Modelling, types of modelling, simulation and types of simulation, Linear equations: Homogeneous and nonhomogeneous equation	1
1.2	Linear algebraic equations: Flow distribution in a pipe network, three stage counter-current extraction	1
1.3	Ordinary differential equations: Co-current shell and tube heat exchanger, Batch reactor, CSTR	1
1.4	Partial differential equations: spherical and cylindrical pellet	1
1.5	Nonlinear algebraic equations: Single stage flash unit	1
1.6	Nonlinear ordinary differential equations: CSTR and PFR	1
1.7	Nonlinear partial differential equations: Unsteady heat conduction, momentum equation	1
2.	**Module 2**	**6**
2.1	**Vectors**: Vector spaces, Matrices, norms and inner products, Metric Space, Normed Linear space, Inner product space	1
2.2	Linear dependence, Dimension of a vector space, subspace, Examples: Splitter-mixer network	1
2.3	Basis, Gram-Schmidt Orthonormalization, Simple problems	1
2.4	Matrices: Determinant, rank, Eigen values and Eigen vectors: simple problems	1
2.5	Fredholm alternative (solvability conditions), Rayleigh's quotient, simple problems	1
2.6	Chemical engineering applications: Linear algebraic equations	1
3.	**Module 3**	**7**
3.1	First order system of homogeneous ordinary differential equations (Initial value problems)	1
3.2	Nonhomogeneous first order ordinary differential equations (IVP)	1
3.3	Non self-adjoint systems	1
3.4	Partial differential equations: Homogeneous and nonhomogeneous equations	1
3.5	Classification of second order PDEs, Boundary conditions	1
3.6	Linearity and superposition	1
3.7	Sturm-Louiville Theory	1
4.	**Module 4**	8
4.1	Infinite dimensional spaces, Metric, norm and inner product in an infinite dimensional space, Completeness	1
4.2	Eigen value problems, Adjoint operators	1
4.3	Classical Eigen value problems: cylindrical coordinates, Spherical coordinates	1
4.4	Fourier series, Rayleigh's Quotient: simple problems	1
4.5	Separation of variables and Fourier transforms, cartesian coordinates, cylindrical coordinates, spherical coordinates	1

4.6	Fourier series and finite Fourier transforms, Laplace transforms	2
4.7	Construction of Green's function for Ordinary differential equations	1
5.	**Module 5**	7
5.1	Uniqueness conditions for Linear and Nonlinear Systems. Maximum principle,	2
5.2	Energy methods, Fredholm alternative,	1
5.3	Monotone iteration method.	2
5.4	Steady State Characteristics of Nonlinear Dynamical Systems: Dynamic systems,	1
5.5	Steady state, Continuation methods.	1

CHT446	COMPOSITE MATERIALS	CATEGORY	L	T	P	CREDIT
		PEC	2	1	0	3

Preamble: The knowledge on Composite Materials has become inevitable for a Chemical Engineer to meet its demand for diverse industrial applications. This course will provide a fundamental knowledge of various types of composite materials, their properties and applications. It also incorporates theory and mechanism, manufacturing techniques and testing of different composite materials, which will help in the selection of appropriate materials for composite synthesis. This course covers a brief introduction to Hybrid composites, Green composites and Nanocomposites which are current composite materials of research interest.

Prerequisite: Nil

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

CO 1	Understand the properties, applications and different types of composite materials, their matrices, reinforcements and additives.
CO 2	Explain the manufacturing techniques of Polymer Matrix, Ceramic Matrix, Metal Matrix and Fibre Reinforced Composites.
CO 3	Analyse the theory and mechanism of composite materials for the selection of matrix and reinforcement materials.
CO 4	Explain the testing procedures of composite materials.
CO 5	Describe the properties and applications of advanced composites.
CO6	Understand the environmental effects, in-service damage types and non-destructive inspection techniques of composites.

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						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 different types of composite materials, their matrices, reinforcements, additives, properties and applications.

1. List the types of reinforcement materials for composites.
2. What are the properties and applications of carbon-carbon composites?
3. Discuss on the fillers of composite materials.

Course Outcome 2 (CO2): Explain the manufacturing techniques of Polymer Matrix, Ceramic Matrix, Metal Matrix and Fibre Reinforced Composites

1. Explain CVD technique for the preparation of composites.
2. Describe melt compounding process.
3. Differentiate between pultrusion and extrusion.

Course Outcome 3(CO3): Analyse the theory and mechanism of composite materials for the selection of matrix and reinforcement materials.

1. What is the principle of composite structure?
2. What are the assumptions made in macro mechanics?
3. Write a note on the mechanics of composite materials.

Course Outcome 4 (CO4): Explain the testing procedures of composite materials

1. How can strength of a composite material be determined?
2. Discuss on the testing methods of composite materials.

3. Briefly discuss on the testing on glass fibres.

Course Outcome 5 (CO5): Describe the properties and applications of advanced composites

1. Discuss on the applications of polymer nanocomposites
2. What are the advantages and disadvantages of composites?
3. Define green composites with examples.

Course Outcome 6 (CO6): Understand the environmental effects, in-service damage types and non-destructive inspection techniques of composites

1. What is composite structure and its advantages?
2. List out the NDT test methods for composites.

Model Question Paper

QP CODE: **PAGES:3**

Reg No:______________

Name :______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

EIGHTH SEMESTER B. TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: CHT446

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

CHT446 COMPOSITE MATERIALS

(2019-Scheme)

PART A

(Answer all questions, each question carries 3 marks)

1. Give examples of rubber matrix composites.
2. How do coupling agents work in a composite? Give examples.
3. Explain pultrusion method.
4. Differentiate between polymer matrix and ceramic matrix composites.
5. What are the assumptions made in macro mechanics?
6. What are the critical issues associated with damage tolerant design?
7. What are the types of composite testing?
8. Write a note on fatigue testing.
9. Define hybrid composites with examples.
10. How do you repair a composite?

PART B

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

Module –1

11. a) Discuss the classification of composite materials based on matrix and reinforcement.

b) Write a note on the properties and applications of laminar and particular composites.

12 a) Explain the various reinforcement materials for composite materials.

b) Discuss on smart composites.

Module –2

13.What are the various steps in processing of PMC? Explain in detail the Filament winding technique for the fabrication of PMC.

14. a) Explain in detail the properties and applications of metal matrix composites.

b) Explain any one technique for the manufacture of Fibre Reinforced Thermoplastics.

Module –3

15. Define failure criteria. Give a review on failure criteria analysis in composite materials.

16. Discuss on the damage tolerance analysis for advanced composites.

Module –4

17. Discuss on the testing of resins.

18. Write a note on mechanical testing of composite materials.

Module –5

19. Write a note on the synthesis, properties and applications of green composites.

20. a) How do you perform inspection on a composite structure?

b) Explain the NDT tests used for composites.

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Syllabus

Module 1: Introduction to composite materials, constituents and classification (9 Hrs.)

Introduction to composite materials, Constituents of composite materials: Reinforcements, Matrix: glass, carbon, Kevlar, boron, asbestos, steel, natural fibres and whiskers-reinforcement fibres, Coupling agents, coatings & fillers, Characteristic features and applications. Classification of composite materials based on matrices and reinforcements- Polymer Matrix Composites - Metal Matrix Composites-Ceramic Matrix Composites-Plastic and Rubber Matrix Composites- Smart Composites-Carbon-Carbon Composites- Intermetallic Composites-Laminated Composites-Fibre reinforced composites-Laminar Composites -Particulate Composites.

Module 2: Manufacturing/Fabrication Techniques (9 Hrs.)

Manufacturing/Fabrication Techniques-Traditional and novel approaches process fundamentals. Polymer Matrix Composites- Fabrication of Fibres, Plastic Fibre Forms, Pre-pregs, Moulding Compounds- Processes, Lay-Ups, Filament Winding, Pultrusion, and Recycling. Ceramic Matrix Composites: Hot-Pressing, Infiltration, In Situ Chemical reaction Techniques, CVD, CVI, Sol-gel. Metal Matrix Composites- Liquid Infiltration, Casting, Solid State Processes, Diffusion Bonding and In Situ Technique. Fibre Reinforced Thermoplastics (FRTP) preparation- brief description of coating process- melt compounding process and dry blending process-injection moulding, rotational moulding and cold forming of reinforced thermoplastics.

Module 3: Composite Mechanics Theory (7 Hrs.)

Composite Mechanics Theory- basic criterion to be adopted in the selection of matrix and reinforcement-mechanics of composite materials-micromechanics and macro mechanics-mechanism of load transfer-minimum and critical fibre content-critical fibre length-law of mixture rule-unidirectional and fibrous composites-effects of fibre orientation on stiffness and strength-bidirectional and random fibre composites-concepts of unit cell-stress analysis of unit cells-toughness of fibrous composites, microscopic stress-strain curves.

Module 4: Testing of composites materials (5 Hrs.)

Testing of composites materials and products for quality control- Brief outlines of testing of glass fibre, testing of resins-testing of products. Failure criteria, Laminate Strength, Stress Concentrations. Key damage mode for composites and composite damage tolerance capabilities. Typical in-service damage types for composites. Non-destructive inspection techniques for detecting damage in composites. Basic types of composite repair and their benefits.

Module 5: Advanced composite materials: Synthesis, Properties and Applications (5 Hrs.)

Advanced composite materials: Synthesis, Properties and Applications of Green Composites, Nanocomposites and Hybrid Composites. Environmental effects in Composites, Advantages and disadvantages of composites with respect to Product Lifecycle Management. General considerations and process involved in composite structural design.

Text Book /References

1. G.Lubin, Handbook of composites, Van Nostrand, New York, 1982.
2. G. Piatti, Advances in composite materials, (1978), Applied Science Publishers Ltd., London.
3. D. Hull, An Introduction to Composite Materials, Cambridge University Press, Cambridge.
4. Mohr.J.G.et al, SPI handbook of Technology and Engineering of reinforced Plastics/Composites, Von Nostrand, New York.
5. P. M. Ajayan, L. S. Schadler, P. V. Braun, Nanocomposite Science and Technology, , (2003), Wiley-VCH Verlag GmbH Co. KGaA, Weinheim.
6. V.V. Vasiliev and E.V. Morozov, Mechanics and Analysis of Composite Materials, , (2001), Elsevier Science Ltd, The Boulevard, Langford Lane, Kidlington, Oxford OX5 lGB, UK.
7. K.K. Chawla, Ceramic matrix composites, 1st Ed., (1993) Chapman & Hall, London.
8. K.K.Chawla, Composite Materials, 2nd Ed., (1987) Springer-Verlag, New York
9. M.O.W. Richardson (Ed)Polymer Engineering Composites. Applied Science Publishers, London.
10. Katz.H.S. & J.V. Milewski, Handbook of Fillers and Reinforcement for plastics- Von Nostrand, New York.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Module 1**	**9**
1.1	Introduction to composite materials, Constituents of composite materials: Reinforcements, Matrix	1
1.2	Glass, carbon, Kevlar, boron, asbestos, steel, natural fibres and whiskers-reinforcement fibres	1
1.3	Coupling agents, coatings & fillers	1
1.4	Characteristic features and applications	1
1.5	Classification of composite materials based on matrices and reinforcements- Polymer Matrix Composites	1
1.6	Metal Matrix Composites-Ceramic Matrix Composites	1
1.7	Plastic and Rubber Matrix Composites- Smart Composites-Carbon-Carbon Composites	1
1.8	Intermetallic Composites-Hybrid Composites-Laminated Composites	1
1.9	Fibre reinforced composites-Laminar composites-Particulate Composites	1
2	**Module 2**	**9**
2.1	Manufacturing/Fabrication Techniques: Traditional and novel approaches process fundamentals	1
2.2	Polymer Matrix Composites- Fabrication of Fibres, Plastic Fibre Forms, Pre-pregs	1
2.3	Moulding Compounds-Processes, Lay-Ups, Filament Winding, Pultrusion, and Recycling.	1
2.4	Ceramic Matrix Composites: Hot-Pressing, Infiltration	1
2.5	In Situ Chemical reaction Techniques, CVD, CVI, Sol-gel methods	1
2.6	Metal Matrix Composites: Liquid Infiltration- Casting	1
2.7	Solid State Processes-Diffusion Bonding and In Situ Technique	1
2.8	Fibre Reinforced Thermoplastics(FRTP) preparation-brief description of coating process-melt compounding process	1
2.9	Dry blending process-injection moulding, rotational moulding and cold forming of reinforced thermoplastics	1
3	**Module 3**	**7**

3.1	Composite Mechanics Theory- basic criterion to be adopted in the selection of matrix and reinforcement	1
3.2	Mechanics of composite materials-micromechanics and macro mechanics-mechanism of load transfer-minimum	1
3.3	Critical fibre content-critical fibre length-law of mixture rule-unidirectional and fibrous composites	1
3.4	Effects of fibre orientation on stiffness and strength-bidirectional and random fibre composites	1
3.5	Concepts of unit cell-stress analysis of unit cells	1
3.6	Toughness of fibrous composites	1
3.7	Microscopic stress-strain curves.	1
4	**Module 4**	**5**
4.1	Testing of composites materials and products for quality control-Brief outlines of testing of glass fibre, Testing of resins-testing of products.	2
4.2	Failure criteria, Laminate Strength, Stress Concentrations. Key damage mode for composites and composite damage tolerance capabilities.	1
4.3	Typical in-service damage types for composites. Non-destructive inspection techniques for detecting damage in composites	1
4.4	Basic types of composite repair and their benefits.	1
5	**Module 5**	5
5.1	Advanced composite materials: Synthesis, Properties and Applications of Green Composites Nanocomposites and Hybrid Composites	2
5.2	Environmental effects in Composites, Advantages and disadvantages of composites with respect to Product Lifecycle Management	2
5.3	General considerations and process involved in composite structural design	1

CHT456	CERAMIC TECHNOLOGY	CATEGORY	L	T	P	CREDIT
		PEC	2	1	0	3

Preamble: An introductory course designed to expose students to the fundamental knowledge and concept of different areas of ceramics and applications. It is designed to introduce the special characteristics and fabrication methods of different classes of ceramics.It also acquaints the student with important areas of Advanced Ceramics; Electro-ceramics, and Bio-ceramics with which students will be motivated to do the project work for development of ceramic materials.

Prerequisite: Nil

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

CO 1	Develop an understanding about ceramics, pottery and glassware.
CO 2	Create a perspective about glasses and its manufacture.
CO 3	Analyse refractories and its manufacture.
CO 4	Gain knowledge about electro ceramics and its manufacture.
CO 5	Develop mastery in bio ceramics and its manufacture.

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	10	10	20
Apply	20	20	50
Analyse	10	10	20
Evaluate			
Create			

Mark distribution

	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

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

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

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Define ceramics and explain their scope.
2. Explain the basic properties of ceramics.

Course Outcome 2 (CO2):

1. Explain the process for the manufacture of glass.
2. What are the different types and applications of glasses?

Course Outcome 3(CO3):

1. Explain the process for the manufacture of refractories.
2. Explain the process for the manufacture of cement and what are the different types of cement and concrete.

Course Outcome 4(CO4):

1. Explain Grain Boundary Barrier Layer Capacitors and Multi-layer Capacitors.
2. Explain Ni-Zn ferrites, Mn-Zn ferrites, Garnets and Hexagonal Ferrites.

Course Outcome 5(CO5):

1. Define biomaterials and explain the scope of biomaterials.
2. Explain the role of Alumina and zirconia in surgical implants and their coatings.

Model Question Paper

QP CODE: **PAGES: 2**

Reg No: _______________ **Name: ____________________________**

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

EIGHTH SEMESTER B. TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: CHT456

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

CERAMIC TECHNOLOGY

PART – A

Answer All the Questions (10 x 3 = 30)

1. Define ceramics and explain their scope.
2. Explain the basic properties of ceramics.
3. What is the function of each rawmaterial in making glass?
4. Define glass and what the properties of glasses.
5. Give any three uses of refractories.
6. Explain the difference between Setting and hardening of cement.
7. Explain the basic ceramic dielectric formulation for capacitors.
8. What are the applications of magnetic ceramics?
9. Define biomaterials and explain the scope of biomaterials.
10. Explain the role of Alumina and zirconia in surgical implants and their coatings?

PART – B

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

Module 1

11. Explain the difference between conventional and advanced ceramics.

OR

12. Explain the classification and types of pottery &whitewares and process for the manufacture of pottery & whitewares.

Module 2

13. Explain the process for the manufacture of glass.

OR

14. What are the different types and applications of glasses?

Module 3

15. Explain the process for the manufacture of refractories.

OR

16. Explain the process for the manufacture of cement and what are the different types of cement and concrete.

Module 4

17. Explain Grain Boundary Barrier Layer Capacitors and Multi-layer Capacitors.

OR

18. Explain Ni-Zn ferrites, Mn-Zn ferrites, Garnets and Hexagonal Ferrites.

Module 5

19. Explain the classification of bio-ceramic materials and characterisation of bio ceramic materials.

OR

20. Explain bioactive glasses and glass ceramics with their clinical applications.

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Syllabus

Module 1 **(7 Hrs.)**

Definition & scope of ceramics and ceramic materials, classification of ceramic materials – conventional and advanced ceramics. Pottery &Whitewares: Classification and type of pottery &whitewares, Elementary idea of manufacturing process technology including body preparation, basic properties and application areas.

Module 2 **(6 Hrs.)**

Glass: Definition of glass, glass raw materials and their functions, elementary concept of glass manufacturing process specially for container glass, different types of glasses, application of glasses.

Module 3 **(7 Hrs.)**

Refractories: Definition of refractory, properties of refractories, classification of refractory, manufacturing process, basic areas of application specially in steel plant. Cement & Concrete: Concept of hydraulic materials, raw materials and manufacturing process, basic compositions, setting and hardening, concrete.

Module 4 **(8 Hrs.)**

Electro Ceramics. Ceramic Capacitors: Ferroelectric ceramic materials; Relaxor ferroelectrics; Basic Ceramic Dielectric formulation for capacitors; Grain Boundary Barrier Layer Capacitors, Multi-layer Capacitors.Ceramic Magnets: Soft and hard ferrites. Ni-Zn ferrites, Mn-Zn ferrites, Garnets and Hexagonal Ferrites. Processing and manufacture of ferrites..Applications of magnetic ceramics.

Module 5 **(7 Hrs.)**

BioCeramics.Definition and scope of bio-materials.Classification of bio-ceramic materials.Alumina and zirconia in surgical implants and their coatings.Bioactive glasses and glass ceramics with their clinical applications.Resorbablebioceramics.Characterization of bio-ceramics.

Text Books

1) F.H Norton, Elements of Ceramics Addison-Wesley Press; 1st edition, January 1, 1952

2) Barsoum, Fundamentals of Ceramics ,CRC Press; 1st edition ,27 November 2002

3) W.D Kingery,Introduction to Ceramics, Wiley,May 1976

4) Singer &Singer,Industrial Ceramics.Springer Netherlands,June 1963.

5)Foundations of materials science and engineering,McGraw-Hill Education, 1993

Reference Books

1) J. H. Chester ,Refractories ,CRC Press; 2nd edition ,31 December 1983

2) A. Paul,Chemistry of Glasses ,Springer 1 July 1982

3)SudhirSen, Ceramic Whitewares ,Oxford& IBH publishing,1992

4) F.M. Lea,Chemistry of cement ,Chemical Publishing Co Inc.,U.S.; 3 September 1971

5) R.C Buchanon,Ceramic Materials for Electronics: Processing, Properties and Applications,Marcel Dekker Inc ,29 May 1986

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Definition & scope of ceramics and ceramic materials**	**7**
1.1	Classification of ceramic materials –conventional and advanced ceramics.	1
1.2	Pottery &Whitewares	2
1.3	Classification and type of pottery &whitewares,	1
1.4	Elementary idea of manufacturing process technology including body preparation	1
1.5	Basic properties and application areas.	2
2	**Glass**	**6**
2.1	Definition of glass, glass raw materials and their functions	2
2.2	Elementary concept of glass manufacturing process specially for container glass,	2
2.3	Different types of glasses	1
24	Application of glasses	1
3	**Refractories,Cement& Concrete**	**7**
3.1	Definition of refractory	1
3.2	Properties of refractories, classification of refractory	2
3.3	Manufacturing process, basic areas of application specially in steel plant.	1
3.4	Concept of hydraulic materials,	1
3.5	Raw materials and manufacturing process, basic compositions,	1
3.6	Setting and hardening, concrete.	1
4	**Electro Ceramics**.	**8**
4.1	Ceramic Capacitors: Ferroelectric ceramic materials	1
4.2	Relaxor ferroelectrics; Basic Ceramic Dielectric formulation for capacitors;	1
4.3	Grain Boundary Barrier Layer Capacitors, Multi-layer Capacitors.	1
4.4	Ceramic Magnets: Soft and hard ferrites	1
4.5	Ni-Zn ferrites, Mn-Zn ferrites, Garnets and Hexagonal Ferrites	2
4.6	Processing and manufacture of ferrites.	1

4.7	Applications of magnetic ceramics.	1
5	**BioCeramics**	**7**
5.1	Definition and scope of bio-materials..	1
5.2	Classification of bio-ceramic materials.	2
5.3	Alumina and zirconia in surgical implants and their coatings.	1
5.4	Bioactive glasses and glass ceramics with their clinical applications	1
5.5	Resorbablebioceramics. Characterization of bio-ceramics.	2

CHT466	TOTAL QUALITY MANAGEMENT	CATEGORY	L	T	P	CREDIT
		PEC	2	1	0	3

Preamble: Total quality management describes a management approach to long-term success through customer satisfaction. In a TQM effort, all members of an organization participate in improving processes, products, services, and the culture in which they work. It uses strategy, data, and effective communications to integrate the quality discipline into the culture and activities of the organization. This course focuses on familiarising the TQM principles, tools and need for various quality systems to ensure the quality of products and processes.

Prerequisite: Nil

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

CO 1	Explain the basic concept of total quality management.
CO 2	Describe various TQM principles.
CO 3	Explain various statistical process control for quality management.
CO 4	Explain TQM tools used in quality management.
CO 5	Explain quality standards and quality auditing.

Mapping of course outcomes with program outcomes

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

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	30
Understand	20	20	40
Apply	20	20	30
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

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

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

Course Level Assessment Questions

Course Outcome 1 (CO1): Explain the basic concept of total quality management.

1. Give the Basic Concepts of TQM.
2. Explain the Analysis Techniques for Quality Costs.
3. What does a typical meeting agenda contain after establishing the TQM?
4. Give the basic steps to strategic quality planning.
5. What are the techniques used for Quality cost?

Course Outcome 2 (CO2): Describe various TQM principles.

1. Give the need for a feedback in an organization.
2. What are the activities to be done using customer complaints?
3. State Maslow‟ s Hierarchy of Needs.
4. State Frederick Herzberg‟ s Two-factor theory.
5. Explain Juran trilogy for Continuous Process Improvement.
6. Explain Kaizen principle.

Course Outcome 3(CO3): Explain various statistical process control for quality management .

1. Explain the seven tools of quality.
2. Define Six Sigma.
3. What is the procedure for constructing the tree diagram?
4. Explain the QC or SPC tools.
5. Plot the control chart for variables and attributes.

Course Outcome 4 (CO4): Explain TQM tools used in quality management.

1. Enumerate the steps to benchmark.
2. What is a QFD?
3. Give the seven basic steps to get an organization started toward TPM.
4. Explain the House of Quality in Quality Function Deployment.
5. What is FMEA? Explain the stages of FMEA.

Course Outcome 5 (CO5): Explain quality standards and quality auditing.

4. What is the need for ISO 9000?
5. Give the objectives of the internal audit.
6. What are the seven elements for the implementation & operations of ISO 14001?
7. Why is ISO 9000 important? Explain briefly.
8. Explain the Benefits of ISO 14000.

Model Question Paper

QP CODE: **PAGES: 3**

Reg No: ______________ **Name: __________________________**

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

EIGHTH SEMESTER B. TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: CHT466

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

TOTAL QUALITY MANAGEMENT

PART – A

Answer All the Questions (10 x 3 = 30)

1. What are the dimensions of quality?
2. State Deming philosophy.
3. List the tools used for feedback.
4. What are the concepts to achieve a motivated work force?
5. Differentiate Population & Sample.
6. List at least five standard formats of matrix diagram.
7. What are the stages of FMEA?
8. What are the goals of TPM?
9. Explain the objectives of the internal audit.
10. What are the four elements for the checking & corrective action of ISO 14001?

PART – B

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

Module 1

11. (a) What are the barriers to TQM implementation?

(b) Explain the analysis techniques of quality cost.

OR

12. (a) Explain the six basic steps of total quality management.

(b) Describe the characteristics of leadership.

Module 2

13. (a) Explain Juran trilogy for Continuous Process Improvement?

(b) Explain Kaizen principle?

OR

14. (a)Explain the PDSA cycle.

(b) How will you improve the performance appraisal system?

Module 3

15. (a) Explain the concepts of Six Sigma.

(b) What are the benefits of an activity network diagram?

OR

16. (a) Explain the Seven Management Tools.

(b)What are the various patterns of scatter diagrams?

Module 4

17. Explain the Bench marking Process and reasons to Benchmark.

OR

18. Explain the House of Quality in Quality Function Deployment?

Module 5

19. .(a) What are the seven elements for the implementation & operations of ISO 14001?

(b)What are the types of Product Evaluation Standards?

OR

20. Explain the implementation and documentation of Quality System?

****

Syllabus

Module 1: Introduction **(7 Hrs.)**

Introduction- Definition of quality – Dimensions of quality – Quality planning – Quality costs – Analysis techniques for quality costs – Basic concepts of total quality management – Historical review – Principles of TQM – Leadership – Concepts – Role of senior management – Quality council – Quality statements –Strategic planning – Deming philosophy – Barriers to TQM implementation.

Module 2: TQM Principles **(8 Hrs.)**

TQM Principles-Customer satisfaction – Customer perception of quality – Customer complaints – Service quality –Customer retention – Employee involvement – Motivation, empowerment, teams, recognition and reward – Performance appraisal – Benefits – Continuous process improvement – Juran trilogy – PDSA cycle – 5S – Kaizen – Supplier partnership – Partnering – Sourcing – Supplier selection – Supplier rating – Relationship development – Performance measures – Basic concepts – Strategy –Performance measure.

Module 3: Statistical Process Control **(7 Hrs.)**

Statistical Process Control-The seven tools of quality – Statistical fundamentals – Measures of central tendency and dispersion – Population and sample – Normal curve – Control charts for variables and attributes – Process capability – Concept of six sigma – New seven management tools.

Module 4: TQM Tools **(7 Hrs.)**

TQM Tools- Benchmarking – Reasons to benchmark – Benchmarking process – Quality Function Deployment (QFD) – House of quality – QFD process – Benefits – Taguchi quality loss function – Total Productive Maintenance (TPM) – Concept – Improvement needs – FMEA – Stages of FMEA.

Module 5: Quality Systems **(6 Hrs.)**

Quality Systems- Need for ISO 9000 and other quality systems – ISO 9000:2000 Quality system – Elements – Implementation of quality system – Documentation – Quality auditing – TS 16949 – ISO 14000 –Concept – Requirements and benefits.

Text Books

1. Besterfiled, D.H. “Total Quality Management”, Pearson Education, Inc. 2003.
2. Zeiri., “Total Quality Management for Engineers”, Wood Head Publishers, 1991.

Reference Books

1. Evans, J. R., and Lidsay, W.M., "The Management and Control of Quality", 5th Edition, South-Western (Thomson Learning), 2002.
2. Oakland.J.S. "Total Quality Management", Butterworth – Hcinemann Ltd., Oxford, 1989.
3. Narayana V. and Sreenivasan, N.S., "Quality Management – Concepts and Tasks", New Age International, 1996.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Module 1 (7 Hrs.)**	
1.1	Definition of quality – Dimensions of quality – Quality planning	1
1.2	Quality costs – Analysis techniques for quality costs	1
1.3	Basic concepts of total quality management – Historical review – Principles of TQM	1
1.4	Leadership – Concepts – Role of senior management	1
1.5	Quality council – Quality statements	1
1.6	Strategic planning – Deming philosophy	1
1.7	Barriers to TQM implementation.	1
2	**Module 2 (8 Hrs.)**	
2.1	Customer satisfaction – Customer perception of quality —Customer complaints	1
2.2	– Service quality –Customer retention	1
2.3	Employee involvement – Motivation, empowerment, teams, recognition and reward	1
24	Performance appraisal – Benefits – Continuous process improvement	1
2.5	Juran trilogy – PDSA cycle-5S – Kaizen	1
2.6	Supplier partnership – Partnering- Sourcing – Supplier selection – Supplier rating	2
2.7	Relationship development – Performance measures – Basic concepts – Strategy –Performance measure.	1
3	**Module 3 (7 Hrs.)**	
3.1	-The seven tools of quality	1
3.2	Statistical fundamentals – Measures of central tendency and dispersion	1
3.3	Population and sample – Normal curve	1
3.4	Control charts for variables and attributes	1
3.5	Process capability – Concept of six sigma	2
3.6	New seven management tools.	1
4	**Module 4 (7 Hrs.)**	
4.1	Benchmarking – Reasons to benchmark	1
4.2	Benchmarking process	1
4.3	Quality Function Deployment (QFD)	1

4.4	House of quality – QFD process – Benefits	1
4.5	Taguchi quality loss function – Total Productive Maintenance (TPM)	1
4.6	Concept – Improvement needs	1
4.7	FMEA – Stages of FMEA.	1
5	**Module 5 (6 Hrs.)**	
5.1	Need for ISO 9000 and other quality systems	1
5.2	ISO 9000:2000 Quality system – Elements – Implementation of quality system	2
5.3	Documentation – Quality auditing – TS 16949 – ISO 14000	2
5.4	Concept – Requirements and benefits.	1

CHT476	ENZYME ENGINEERING	CATEGORY	L	T	P	CREDIT
		PEC	2	1	0	3

Preamble: The course deals with basic topics about enzymes such as classification, production, purification and applications. A detailed study of kinetics of enzyme catalysed reactions is included. Immobilization of enzymes, mass transfer concepts and performance of batch, plug flow and continuous stirred tank reactors for enzyme catalysed reactions are also covered.

Prerequisite: Nil

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

CO 1	Classify enzymes along with their applications in different fields.
CO 2	Analyze enzyme kinetics and apply the same in the design of reactors.
CO 3	Outline the types and methods of immobilization of enzymes.
CO 4	Summarize the various types of enzyme reaction systems and reactors.
CO 5	Explain the application of enzymes in health care, environment and 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											
CO 2	3		3									
CO 3	3											
CO 4	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): Classify enzymes along with their applications in different fields.

1. List out the six major classes of enzymes as proposed by Enzyme commission, International Union of Biochemists, in the year 1961.
2. Define the following terms
   a. Holoenzyme
   b. Apoenzyme
   c. Coenzyme
   d. Cofactors
3. Discuss the Koji technique for enzyme production.

Course Outcome 2 (CO2): Analyze enzyme kinetics and apply the same in the design of reactors.

1. What is enzyme specificity?
2. Brief the following: Proximity effect, Orientation effect and Turn over number
3. Determine the MM parameters v_{max} and K_m for the reaction:

   Urea + Urease → [Urea Urease] → 2 NH_3+ CO_2 + Urease

   The rate of reaction is a function of urea concentration as shown in the following table

[C]urea, (kmol/m^3)	-r urea (kmol/m^3- s)
0.20	1.08
0.02	0.55

0.01	0.38
0.005	0.2
0.002	0.09

Course Outcome 3(CO3): Outline the types and methods of immobilization of enzymes.

1. What is enzyme immobilization? What is its importance?
2. Explain various methods of enzyme immobilization.
3. Describe the film and pore diffusion effects on kinetics of immobilized enzyme reactions.

Course Outcome 4 (CO4): Summarize the various types of enzyme reaction systems and reactors

1. Discuss batch and fed batch reactors for enzyme catalysed reactions.
2. Develop the performance equation for enzyme catalysed reactions in an ideal plug flow reactor.
3. Sketch neat diagrams for CSTR designs for enzyme catalysed reactions.

Course Outcome 5 (CO5): Explain the application of enzymes in health care, environment and industry

1. Discuss briefly enzyme biosensors
2. List out three industrial applications of enzymes.
3. Discuss in detail the use of insulin for diabetes treatment.

Model Question Paper

QP CODE: **PAGES: 3**

Reg No: _____

_________ **Name: ___________________________**

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

EIGHTH SEMESTER B. TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: CHT 476

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

ENZYME ENGINEERING

PART – A

Answer All the Questions (10 x 3 = 30)

1. List out the six major classes of enzymes as proposed by Enzyme commission, International Union of Biochemists, in the year 1961.
2. Define the following terms
   a. Holoenzyme
   b. Apoenzyme
   c. Coenzyme
   d. Cofactors
3. What is enzyme specificity?
4. Brief the following: Proximity effect, Orientation effect and Turn over number
5. What is enzyme immobilization? What is its importance?
6. Outline the process of microencapsulation.
7. Discuss batch and fed batch reactors for enzyme catalysed reactions.
8. Sketch neat diagrams for CSTR designs for enzyme catalysed reactions.
9. List out three industrial applications of enzymes.
10. Differentiate between hydrolytic and proteolytic enzymes.

PART – B

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

Module 1

11. Discuss the Koji technique for enzyme production.

OR

12. Explain the production of enzymes from plant extracts.

Module 2

13. Determine the MM parameters v_{max} and K_m for the reaction:

Urea + Urease -------- [Urea Urease]----------2 NH_3+ CO_2 + Urease

The rate of reaction is a function of urea concentration as shown in the following table

[C]urea, (kmol/m^3)	-r urea (kmol/m^3- s)
0.20	1.08
0.02	0.55
0.01	0.38
0.005	0.2
0.002	0.09

OR

14. Explain feedback inhibition with a suitable example.

Module 3

15. Explain various methods of enzyme immobilization.

OR

16. Describe the film and pore diffusion effects on kinetics of immobilized enzyme reactions

Module 4

17. Develop the performance equation for enzyme catalysed reactions in an ideal plug flow reactor

OR

18. Explain immobilized enzyme reaction kinetics in a CSTR.

Module 5

19. Discuss briefly enzyme biosensors.

OR

20. Discuss in detail the use of insulin for diabetes treatment.

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Syllabus

Module 1: Classification and Production of Enzymes (7 Hrs.)

Classification and Production of Enzymes: Classification of enzymes, commercial application of enzymes in food, pharmaceutical and other industries. Enzymes for analytical and diagnostic applications. Production and purification of crude enzymes. Extracts from plant, animal and microbial sources.

Module 2: Mechanism of Enzyme Action (7 Hrs.)

Mechanism of Enzyme Action**:** Concept of active site, enzyme-substrate complex and enzyme action. Simple enzyme kinetics with one substrate. Michaelis-Menten kinetics. Evaluation of parameters in Michaelis-Menten kinetic equation. Types of inhibition. Influences of pH, temperature, fluid forces, chemical agents and irradiation on chemical activity.

Module 3: Enzyme Immobilization (7 Hrs.)

Enzyme Immobilization: Physical and chemical techniques for enzyme immobilization, adsorption, matrix entrapment, encapsulation, cross-linking, covalent binding. Advantages and disadvantages of different immobilization techniques. Application of immobilized enzyme systems. Mass Transfer effects in immobilized enzyme systems. Analysis of film and pore diffusion effects on kinetics of immobilized enzyme reactions.

Module 4: Reactors and Operations (7 Hrs.)

Reactors and Operations: Batch operation of a stirred reactor, Time course for batch enzyme reaction**.** Continuous operation in a stirred tank reactor. Immobilized enzyme reaction in a CSTR and plug flow reactor.

Module 5: Applications (7 Hrs.)

Applications: Enzyme biosensors**.** Application of enzymes in analysis, design of enzyme electrodes and their application in industry, healthcare and environment.

Text Books

1. Gerharts, W. "Enzymes in Industry – Production and application.
2. James E Bailley & David F Ollis, Biochemical Engineering Fundamentals, McGraw Hill
3. Pauline M. Doran, "Biochemical Engineering Principles", Academic Press.
4. Taylor R.F. (Ed.) "Protein immobilization – Fundamentals and application"

Reference Books

1. Zubay G., Biochemistry, Maxwell Macmillan International Education
2. Rao, D.G., Introduction to Biochemical Engineering., Tata McGraw Hill Publishing Company

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Module 1**	**7**
1.1	Classification of enzymes, commercial application of enzymes in food, pharmaceutical and other industries	2
1.2	Enzymes for analytical and diagnostic applications.	2
1.3	Production and purification of crude enzymes.	2
1.4	Extracts from plant, animal and microbial sources.	1
2	**Module 2**	**7**
2.1	Concept of active site, enzyme-substrate complex and enzyme action.	1
2.2	Simple enzyme kinetics with one substrate. Michaelis-Menten kinetics.	2
2.3	Evaluation of parameters in Michaelis-Menten kinetic equation.	2
2.4	Types of inhibition.	1
2.5	Influences of pH, temperature, fluid forces, chemical agents and irradiation on chemical activity.	1
3	**Module 3**	**7**
3.1	Physical and chemical techniques for enzyme immobilization, adsorption, matrix entrapment, encapsulation, cross-linking, covalent binding.	2
3.2	Advantages and disadvantages of different immobilization techniques. Application of immobilized enzyme systems.	1
3.3	Mass Transfer effects in immobilized enzyme systems.	2
3.4	Analysis of film and pore diffusion effects on kinetics of immobilized enzyme reactions	2
4	**Module 4**	**7**
4.1	Batch operation of a stirred reactor.	2
4.2	Time course for batch enzyme reaction.	1
4.3	Continuous operation in a stirred tank reactor.	2
4.4	Immobilized enzyme reaction in a CSTR and plug flow reactor.	2
5	**Module 5**	**7**
5.1	Enzyme biosensors.	2
5.2	Application of enzymes in analysis.	2
5.3	Design of enzyme electrodes and their application in industry, healthcare and environment	3

SEMESTER VIII

PROGRAM ELECTIVE V

CHT418	SOLID WASTE MANAGEMENT	CATEGORY	L	T	P	CREDIT
		PEC	2	1	0	3

Preamble: The Objectives of this course is to impart the basic concepts of solid waste management and to develop understanding about recovery, reuse and disposal of solid waste.

Prerequisite: Nil

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

CO 1	Explain municipal solid waste management systems with respect to its physical, chemical and biological properties.
CO 2	Select appropriate methods for solid waste collection and optimize the route for transportation.
CO 3	Understand the design and operation of landfills.
CO 4	Compare disposal methods of MSW by applying specific criteria.
CO 5	Understand the recovery and recycling methods of waste management.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3		3				2					
CO 2	3	3	3	3		3	2			-		3
CO 3	3	3	3				3					3
CO 4	3	3	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	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): Explain municipal solid waste management systems with respect to its physical, chemical and biological properties.

1. What are the sources of commercial solid wastes?
2. Describe the sampling techniques of solid wastes.
3. How will you determine the chemical composition of municipal solid waste?

Course Outcome 2 (CO2): Select appropriate method for solid waste collection and optimize the route for transportation.

1. Describe onsite storage methods of solid waste.
2. Write a note on solid waste transportation methods.
3. Differentiate between hauled and stationary container system.

Course Outcome 3(CO3): Understand the design and operation of landfills.

1. Describe sanitary landfilling?
2. What are the factors to be considered for land farming of solid waste?
3. Explain deep well injection method.

Course Outcome 4 (CO4): Compare disposal methods of MSW by applying specific criteria.

1. Explain windrow composting.
2. Explain the design and operation of an incinerator.
3. What is the principle of pyrolysis of solid waste? Explain.

Course Outcome 5 (CO5): Understand the recovery and recycling methods of waste management.

1. Write a note on solid waste management practices in India.
2. Explain Integrated waste management system.

3. What are the sources of hazardous solid? Explain the methods to control hazardous waste.

Model Question Paper

QP CODE: **PAGES:**

Reg No: _______________________

Name: _________________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
EIGHTH SEMESTER B. TECH DEGREE EXAMINATION, MONTH & YEAR
Course Code: CHT418

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

SOLID WASTE MANAGEMENT
PART – A

Answer All the Questions, each question carries 3 marks

1. Explain how solid wastes are classified.
2. What are the various sources of solid wastes?
3. What are the various solid waste processing methods?
4. Write a note on solid waste collection systems.
5. Explain gas movement in sanitary landfills.
6. Write a note on disposal methods for solid waste.
7. What are the principles of anaerobic digestion?
8. Describe pyrolysis of solid waste.
9. Name the sources of hazardous solid waste.
10. Explain Data Base Management System.

(10 x 3 = 30)

PART – B

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

Module 1

11. a. Explain physical, chemical and biological characteristics of solid waste. 10marks
b .Write a note on sources and classification of solid waste. 4marks

OR

12. a. How will you determine the energy content and chemical content of solid waste? 9marks
b. What are the factors that affect the solid waste generation rates? 5marks

Module 2

13.a Differentiate between primary and secondary waste collection methods with examples. 9marks
b Explain onsite storage methods of solid waste. 5marks

OR

14. a. Differentiate between hauled container systems and stationary container systems.

8marks

b .How will you determine the vehicle and labour requirements for transportation of solid waste. 6marks

Module 3

15. a Explain the control methods for leachate movement during the disposal of solid wastes. 6 marks

b Describe deep well injection method. 9 marks

OR

16. Explain in detail the design and operation of sanitary land fill for the management of solid waste. 14marks

Module 4

17. Differentiate between windrow and aerated static pile composting. What are the factors that affect composting? Explain. 14marks

OR

18. What is meant by incineration? With a neat sketch explain the working of a moving grate incinerator and also mention the operating conditions involved. 14marks

Module 5

19. .a What are the various solid waste management methods practised in India? Explain. 10marks

b Explain integrated waste management. 4marks

OR

20. a Explain recovery, recycle and reuse of solid waste. 7marks

b. Describe geographic information system and remote sensing data in planning and management of MSW. 7marks

(5 x 14 = 70)

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Syllabus

Module 1 **(8 Hrs.)**

Solid wastes-Sources, nature and characteristics - types of solid waste, Residential, Commercial, Hazardous wastes, and Industrial wastes, Properties of Solid wastes, Waste generation, Sampling and analysis, Characteristics of solid wastes - Energy content, Chemical content, Estimation of chemical composition of a solid waste sample. Generation rates - Estimation of solid waste quantities - Factors affecting generation rates.

Module 2 **(7 Hrs.)**

Collection of solid waste, On-site storage methods-containers, their type, size and location, Collection Systems-Vehicles, Types of collection system –HCS, SCS, Determination of vehicle and labor requirements, Collection routing, route balancing and transfer stations, Transfer methods, Processing methods.

Module 3 **(7 Hrs.)**

Disposal methods such as sanitary landfill –methods, leachate in landfills – control of leachate movement, Gas movement – control, Design and operation of landfills, Landfarming, deep well injection etc.

Module 4 **(7 Hrs.)**

Composting, Factors affecting composting, Aerobic composting and anaerobic digestion, Design principles. Incineration, Municipal incinerators, Grates, Furnances, Design principles,
Pyrolysis of solid waste.

Module 5 **(6 Hrs.)**

Recovery, Recycle and Reuse-Material and Energy recovery operations. Overview of solid waste management practices in India. Industrial and Hazardous solid waste management, Integrated Waste Management (IWM), Basics of Data base Management System (DBMS), Geographic Information System (GIS) and Remote Sensing data in planning and management of MSW**.**

Text Books

1. Howard S.Peavy, Donald R.Rowe, George Tchobanoglous, Environmental Engineering, Mc Graw Hill. New York, 1985.
2. Frank Kreith, George Tchobanoglous, Handbook of Solid Waste Management, McGraw Hill Publishers, 2002.

Reference Books

1. P.Aarne Vesilind and William Worrell, Solid waste Engineering, Cengage Learning, Asia Pte Limited, 2012.
2. Gerard Kiely, Environmental Engineering, McGraw Hill ,New Delhi,2008.
3. Nicholas P. Cheremisinoff, Handbook of Solid Waste Management and Waste Minimization Technologies ‚ Butterworth-Heinemann,2002.
4. Luis F. Diaz, George M. Savage, Linda L. Eggerth, Larry , Rosenberg, Solid Waste Management, United Nations Environment Programme, .Paris, 2005.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Module 1**	**8**
1.1	Solid wastes-Sources, nature and characteristics - types of solid waste, Residential, Commercial ,Hazardous wastes, and Industrial wastes,	2
1.2	Types of solid waste, Residential, Commercial ,Hazardous wastes, and Industrial wastes	1
1.3	Properties of Solid wastes	1
1.4	Sampling and analysis	1
1.5	Characteristics of solid wastes	1
1.6	Estimation of chemical composition of a solid waste sample	1
1.7	Generation rates - Estimation of solid waste quantities - Factors affecting generation rates.	1
2	**Module 2**	**7**
2.1	Collection of solid waste, On-site storage methods-containers, their type, size and location	2
2.2	Collection systems-Vehicles, Types of collection system –HCS, SCS	2
2.3	Determination of vehicle and labour requirements	1
24	Collection routing, route balancing	1
2.5	transfer stations, Transfer methods, Processing methods	1
3	**Module 3**	**7**
3.1	Disposal methods such as sanitary landfill –methods	1
3.2	Leachate in landfills	1
3.3	Control of leachate movement, Gas movement control	1
3.4	Design and operation of landfills	2
3.5	Landfarming, deep well injection	1
3.6	Changes affecting feasibility and changes affecting optimality	1
4	**Module 4**	**7**
4.1	Composting, Factors affecting composting	1
4.2	Aerobic composting	1
4.3	anaerobic Digestion- Design principles	2
4.4	Incineration, Municipal incinerators, Grates, Furnances, Design principles.	2
4.5	Pyrolysis of solid waste	1

5	**Module 5**	**6**
5.1	Recovery, Recycle and Reuse-Material and Energy recovery operations.	1
5.2	Overview of solid waste management practices in India	1
5.3	. Industrial and Hazardous solid waste management	2
5.4	Integrated Waste Management (IWM), Basics of Data base Management System (DBMS)	1
5.5	Basics of Geographic Information System (GIS) and Remote Sensing data in planning and management of MSW	1

CHT428	NON-CONVENTIONAL PETROLEUM RESOURCES	CATEGORY	L	T	P	CREDIT
		PEC	2	1	0	3

Preamble: Non-conventional petroleum resources aim to identify the formation and geographic distribution of non-conventional hydrocarbon resources. On studying this course, the student can understand and characterize the source and reservoir rocks. The basic principles of conversion of coal and gas to oil can be studied in this course. On studying this course student can analyze the environmental and economic consequences of non- conventional hydrocarbon resources.

Prerequisite: Nil

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

CO 1	Apply the concepts related to exploration, occurrence and origin of Shale Gas Reservoirs.
CO 2	Explain the concepts related to formation and properties of Coal Bed Methane.
CO 3	Summarize and apply the concepts related to formation and properties of gas hydrates.
CO 4	Analyse different processes for the conversion of coal and gas to oil.
CO 5	Demonstrate awareness related to economic and environmental considerations of non-conventional oil and gas.

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

Assessment Pattern

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination**
	1	**2**	
Remember	40	40	40
Understand	20	20	20
Apply	20	20	20
Analyse	20	20	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 gas combustion retorting process for the production of shale oil from oil shale with the help of a neat process flow diagram

Course Outcome 2 (CO2):

Define rank of coal and vitrinite reflectance of coal.

Course Outcome 3(CO3):

Describe the exploration of gas hydrates by index mineral technique

Course Outcome 4 (CO4):

Derive an expression for change in entropy and enthalpy upon adsorption of gas in coal reservoir

Course Outcome 5 (CO5):

Illustrate the economic impact of shale gas development.

Model Question Paper

QP CODE: **PAGES: 3**

Reg No: _______________ **Name: ___________________________**

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

EIGHTH SEMESTER B. TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: CHT428

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

NON-CONVENTIONAL PETROLEUM RESOURCES

PART – A

Answer All the Questions (10 x 3 = 30)

1. List the advantages of in-situ bitumen extraction from oil sand.

2. Describe Steam Assisted Gravity Damage (SAGD) technique for the production of oil from sand.

3. Explain direct retorting and its advantages in the production of shale oil.

4. Describe the cracking fluid used for shale gas production.

5. Explain biogenic and thermogenic coal bed methane formation

6.Illustrate two forms in which coal bed methane is stored in the reservoir

7. Describe chemical injection method for the extraction of gas hydrates.

8. List out the considerations to be included in the well completion of the gas hydrate production.

9. Write a short note on treating produced water.

10. Describe shortly the main environmental considerations of in non conventional petroleum resources.

PART – B

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

Module 1

11a) Differentiate between solvent extraction and steam soak method for the recovery of heavy oil (7 marks)

b) Describe steam flooding and in-situ combustion method for the recovery of heavy oil. (7 marks)

OR

12a). Describe ex-situ production of oil sand (7 marks)

b) Write a brief note on worldwide occurrence of oil shales (7 marks)

Module 2

13a). Explain the well casing construction procedure followed in the shale gas production with the help of a neat sketch (7 marks)

c) Discuss the best practice for the environmental protection in the shale gas production

(7 marks)

OR

14a). Describe hydraulic fracturing technique with a neat sketch for the production of shale gas. (9 marks)

b) Write a short note the applications of shale gas (5 marks)

Module 3

15a). Differentiate between pre mining drainage method and post mining drainage method for the production of coal seam gas. (9 marks)

b). Write down the significance of rank of coal and vitrinite reflectance value in C.B.M generation in coal seam (5 marks)

OR

16a). Discuss in detail the retention and release mechanism in CBM reservoirs (9 marks)

b) Write a short note on thermodynamics of coal bed methane (5 marks)

Module 4

17a). Explain geochemical technique for the exploration of gas hydrates. (7 marks)

b) Discuss the effect of gas source and water source in the formation of gas hydrates. (7 marks)

OR

18. Develop the equations which provide the formation and accumulation of gas hydrates in a uniform porous media. (9 marks)

b) Give out the principle of depressurization technique for the production of gas hydrates.

(5 marks)

Module 5

19a. Describe in detail the processes involved in gas conversion to oil. (9 marks)

b) Compare low temperature carbonization with high temperature pyrolysis of coal.

(5 marks)

OR

20a). Explain various types of Fischer-Tropsch reactors used in the CTL technology.

(9 marks)

b) Write a short on economical considerations of non-conventional oil and gas.

(5 marks)

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Syllabus

Module 1: Non-Conventional Oil **(8 Hrs.)**

Non-Conventional Oil: Introduction, geology of heavy oil, extra heavy oil, tar, sand and bituminous oil shales, their origin and occurrence worldwide, resources, reservoir characteristics, new production technologies.

Module 2: Shale Gas **(7 Hrs.)**

Shale Gas: Introduction and present status of shale gas. Formation and properties of shale gas. Drilling and completion of shale gas. Uses and applications of shale gas. Environmental issues in shale gas exploration. Future prospects of shale gas.

Module 3: Coal Bed Methane (CBM) **(6 Hrs.)**

Coal Bed Methane (CBM): Formation and properties of coal bed methane. Thermodynamics of coal bed methane. Exploration and evaluation of CBM. Hydro-fracturing of coal seam. Production installation and surface facilities. Well operations and production equipment.

Module 4: Gas Hydrates **(6 Hrs.)**

Gas Hydrates: Introduction and present status of gas hydrates. Formation and properties of gas hydrates. Thermodynamics of gas hydrates. Drilling and completion of gas hydrates wells. Gas hydrates accumulation in porous media. Gas extraction from gas hydrates. Uses and applications of gas hydrates.

Module 5: Coal and Gas Conversion to Oil **(8 Hrs.)**

Coal and Gas Conversion to Oil: Introduction, classification and principles, pyrolysis, theoretical aspect of processes involved in conversion, Environmental and Economic Considerations: Environmental considerations of non-conventional oil and gas. Treating and disposing produced water.

Text/ Reference Books

1. Carroll John, Natural Gas Hydrates: A guide for engineers, Gulf Professional Publications, 2014.
2. Farouq Ali, S M, Jones J A and Meldau R F, Practical Heavy Oil Recovery, SPE, 1997.
3. James T. Bartis, Frank Camm, David S. Ortiz, Producing Liquid Fuels from Coal, Prospects and Policy Issues. NETL, 2008.
4. Pramod Thakur, Steve Schatzel and KashyAminian, Coal BedMethane: From Prospects to Pipeline, Elsevier, 2014.
5. Rafiqul Islam, M, Unconventional Gas Reservoirs: Evaluation, Appraisal and Development, Gulf Professional Publishing, 2014.
6. Warner, H.R., Petroleum Engineering Handbook, Volume VI, Emerging and Peripheral Technologies, 2007.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Module 1**	**8**
1.1	Introduction, geology of heavy oil	1
1.2	Extra heavy oil, tar, sandand bituminous oil shales, their origin and occurrence worldwide	3
1.3	Resources, reservoir characteristics	2
1.4	New production technologies	2
2	**Module 2**	**7**
2.1	Introduction and present status of shale gas	2
2.2	Formation and properties of shale gas	1
2.3	Drilling and completion of shale gas. Uses and applications of shale gas	2
24	Environmental issues in shale gas exploration	1
2.5	Future prospects of shale gas	1
3	**Module 3**	**6**
3.1	Formation and properties of coal bed methane	1
3.2	Thermodynamics of coal bed methane	1
3.3	Exploration and Evaluation of CBM	1
3.4	Hydro-fracturing of coal seam	1
3.5	Production installation and surface facilities	1
3.6	Well operations and production equipment	1
4	**Module 4**	**6**
4.1	Introduction and present status of gas hydrates	1
4.2	Formation and properties of gas hydrates	1
4.3	Thermodynamics of gas hydrates	1
4.4	Drilling and completion of gas hydrates wells. Gas hydrates accumulation in porous media	2
4.5	Gas extraction from gas hydrates. Uses and applications of gas hydrates.	1
5	**Module 5**	**8**
5.1	Introduction, classification and principles of conversion	2
5.2	Pyrolysis, theoretical aspect of processes involved in conversion	2
5.3	Environmental and Economic Considerations: Environmental considerations of non-conventional oil and gas	2
5.4	Treating and disposing produced water.	2

CHT438	PROCESS OPTIMIZATION	CATEGORY	L	T	P	CREDIT
		PEC	2	1	0	3

Preamble: Process Optimization is a discipline to evaluate the best possible values of process or process sub-system variables to improve its efficiency by applying analytical and numerical methods. The tools of Process Optimization are essentially useful in all the fields of Science and Engineering from basic analysis to complete design of a system. This course aims to familiarize the students with techniques, which are frequently applied to optimize process or process sub-system variables. It also provides a detailed computational approach to analyze and design any chemical process, where such an approach is appropriate.

Prerequisite: Nil

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

CO 1	Identify the importance and values of mathematical modelling and Process Optimization to analyze and design any chemical process.
CO 2	Formulate Linear and non-linear Programming models to develop mathematical models of basic Chemical Engineering problems.
CO 3	Apply Linear and non-linear optimization techniques and algorithms to solve basic Chemical Engineering problems.
CO 4	Understand the concept and solve various multivariable optimization problems.
CO 5	Apply different optimization techniques in Chemical Engineering process design.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3	3									
CO 2	3	3	3									
CO 3	3	3	3									
CO 4	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	10	10	20
Apply	20	20	50
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): Identify the importance and values of mathematical modelling and Process Optimization to analyze and design any chemical process.

1. Define process optimization.
2. Explain importance of mathematical modelling in process optimization.
3. Write down the basic structure of an optimization problem in the mathematical form.
4. Write any three examples of optimization areas in chemical engineering.

Course Outcome 2 (CO2): Formulate Linear and non-linear Programming models to develop mathematical models of basic Chemical Engineering problems.

1. Determine convexity and concavity of functions.
2. State necessary and sufficiency condition for optimum points of functions.
3. Define unimodal function with a mathematical statement. Give a graphical representation.
4. A toy manufacturing organization manufactures two types of toys A and B. Both the toys are sold at Rs.25 and Rs.20 respectively. There are 2000 resource units available every day from which the toy A requires 20 units while toy B requires 12 units. Both of these toys require a production time of 5 minutes. Total working hours are 9 hours a day. Formulate the optimization problem to maximize the profits?

Course Outcome 3(CO3): Apply Linear and non-linear optimization techniques and algorithms to solve basic Chemical Engineering problems.

1. Find the minimum of $f(x) = x(x - 5\pi)$ by one iteration using Quasi-Newton's method with initial point 2 and step size 0.01

2. Describe in detail the procedure of quadratic interpolation method to find the minimum of a univariate function.
3. Find the minimum point of $f(x) = x(e^{-x} + \sin 2x)$ in the interval [1.5, 3.5] using Golden section method with 2 iterations.

Course Outcome 4 (CO4): Understand the concept and solve various multivariable optimization problems.

1. Find the dimensions of the biggest rectangle that can be inscribed in a right triangle with dimensions 6cm,8cm and 10 cm.
2. Minimize the function $f(X) = 8x_1^2 + 17x_2^2 - 20x_1x_2 - 32x_1 + 40x_2$ by 2 iterations using Steepest Descent method starting from $\begin{bmatrix} 1 \\ -1 \end{bmatrix}$.
3. A toy manufacturing organization manufactures two types of toys A and B. Both the toys are sold at Rs.25 and Rs.20 respectively. There are 2000 resource units available every day from which the toy A requires 20 units while toy B requires 12 units. Both of these toys require a production time of 5 minutes. Total working hours are 9 hours a day. Formulate and solve the optimization problem to maximize the profits?

Course Outcome 5 (CO5): Apply different optimization techniques in Chemical engineering process design.

1. Formulate the objective function and constrain equations to find optimum design of shell-and-tube heat exchanger.
2. Derive equations for Optimum intermediate concentration and time of reaction for series reaction in batch reactor.

Model Question Paper

QP CODE: **PAGES: 3**

Reg No: ______________________

Name: ________________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
EIGHTH SEMESTER B. TECH DEGREE EXAMINATION, MONTH & YEAR
Course Code: CHT438

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

PROCESS OPTIMIZATION

PART – A

Answer All the Questions (10 x 3 = 30)

1. Define process optimization. Write any two chemical engineering applications of optimization.
2. Define Convex functions.
3. State Necessary and sufficient conditions for optimum of univariate unconstrained functions.
4. Describe one-dimensional search method with accelerated step size.
5. State Kuhn-Tucker conditions for local optimality.
6. Minimize the given function by direct substitution:

   f(x) = $4x_1^2$+$5x_2^2$: Subject to: $2x_1$+$3x_2$= 6
7. Write the general form of a LPP.
8. Write the procedure in detail for finding the minimum of a univariate function using Golden section method.
9. Define pay Back Period (PBP).
10. What you mean by formulation of an optimization problem? What are the major components of Economic objective function?

PART – B

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

Module 1

11. (a) Define convex function with mathematical statement. Give graphical representation. Write any three properties of convex function. (7)

    (b) Decide whether the function $f(x_1, x_2) = (x_1 + 1)^4 + x_1x_2 + (x_2 + 1)^4$ is convex or concave $\forall\, x_1, x_2 > 0$ (7)

OR

12. (a) Classify the general optimization problems. State the essential features of optimization problems. (6)

    (b) Find the extreme points of the function $f(X) = 2({x_1}^2 + {x_2}^2)e^{-({x_1}^2+{x_2}^2)}$ (8)

Module 2

13. (a) Find the extreme points of the function $f(X) = x_1^2 + x_2^2 + x_3^2 + x_1x_2 + x_1x_3 + x_2x_3 - 7x_1 - 8x_2 - 9x_3 + 101$ (7)

(b) Minimize the function $f(x) = e^{-x} + x^2$ in [-4,4] using quadratic interpolation method with 2 iterations. (7)

OR

14. (a) Write the procedure for dichotomous search method in detail.

(b) Find the minimum point of the function $f(x) = x^4 - 3.1x^2 + 2x + 1$ in the interval [1,3] with 2 iterations from starting point $x_0 = 1.8$ using Newton's method.

Module 3

15. (a) Find maximum and minimum of $f(x, y) = 3x + y$ subjected to the constraint$x^2 + y^2 = 10$ using Lagrange multiplier method. (7)

(b) Find the dimensions of a box of largest volume that can be inscribed in a sphere of radius R by direct substitution method (7)

OR

16. (a). Using Kuhn-Tucker conditions, find the value(s) of β for which the point x_1^*=1, x_2^*=2 will be optimal to the given problem

maximize $f(X) = 2x_1 + \beta x_2$ subject to

$$g_1(X) = x_1^2 - x_2^2 - 5 \leq 0$$

$$g_2(X) = x_1 - x_2 - 2 \leq 0$$

(7)

(b). Find the maximum and minimum values of $f(x, y) = x^2 + y^2 + x$ on the unit circle using Lagrange multiplier method. (7)

Module 4

17. (a) Two chemicals C_1 and C_2 are used to manufacture products of grade A and B.one unit of grade A product contains 3 units of C_1 and 4 units of C_2. One unit of grade B product contains 5 units of C_1 and 3 units of C_2. Minimum available quantity of chemicals C_1 and C_2 per day is 50 and 60 units respectively. Production cost per day per unit of grade A product is Rs.100 and that for grade B product is Rs.80. Solve the LPP graphically to find the number of units of two products to be manufactured to minimize the production cost.

(10)

(b) Describe in detail the procedure of quadratic interpolation method to find the minimum of a univariate function. (4)

OR

18. (a) In the minimization of $f(X) = 5x_1^2 + x_2^2 + 2x_1x_2 - 12x_1 - 4x_2 + 8$ starting at $\begin{bmatrix} 0 \\ -2 \end{bmatrix}$ find a search direction conjugate to the x_2 axis. (7)

(b). Minimize the function $f(X) = x_1^2 + 4x_2^2$ by 2 iterations using Steepest Descent method starting from $\begin{bmatrix} -2 \\ -2 \end{bmatrix}$ (7)

Module 5

19. (a) Formulate the mathematical equations to find Optimum thermal insulation thickness for cylindrical pipe. (7)

(b) Formulate the problem to find Optimum reflux ratio for a staged-distillation column.

OR

20. (a)Define profitability. Describe various measures of profitability. (6)

(b) Formulate equations to find optimal flow of an incompressible fluid with density ρ and viscosity μ in a pipe considering the trade-off between the energy costs for transport and the investment charges. (8)

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Syllabus

Module 1: Introduction to Process optimization & overview of mathematical functions (8 Hrs.)

Introduction to Process optimization & overview of mathematical functions**:** Scope and hierarchy of optimization, Typical chemical engineering applications of optimization. Statement of an Optimization Problem and its essential features, Classification of Optimization Problems and its essential features. Mathematical modelling of typical chemical engineering optimization problems. Nature and classification of mathematical functions, Graphical representation of univariate and bivariate functions (using MATLAB / Python etc.). Unimodal functions, determination of convexity and concavity of single and multivariate functions.

Module 2: Analytical & Numerical methods for unconstrained optimization problems (7 Hrs.)

Analytical & Numerical methods for unconstrained optimization problems**:** *Analytical methods*: Necessary and sufficient conditions for optimum of univariate unconstrained functions. *Numerical methods*: One dimensional gradient-free search methods (Fixed & accelerated step size, Dichotomous search, Fibonacci search, golden-section method and quadratic interpolation), One dimensional gradient search methods (Newton's method and Quasi-Newton method).

Module 3: Analytical methods for constrained multivariate optimization problems (6 Hrs.)

Analytical methods for constrained multivariate optimization problems: *Nonlinear programming with equality constraints*: method of direct substitution, Lagrange multiplier method, *Nonlinear programming with inequality constraints*: Kuhn-Tucker conditions for local optimality, Complex method, Rosen's gradient projection method.

Module 4: Numerical methods for unconstrained & constrained multivariate optimization problem (7 Hrs.)

Numerical methods for unconstrained & constrained multivariate optimization problem**s:** *Unconstrained multivariate optimization problems*: Univariate search, Powell's method, method of steepest descent, Fletcher-Reeve's conjugate-gradient method, Newton's method. *Constrained multivariate optimization problems*: Basic concepts and graphical representation of Linear programming, graphical solution, Simplex method and two-phase simplex method.

Module 5: Optimization case studies in chemical engineering (7 Hrs.)

Optimization case studies in chemical engineering: *Economic considerations*: Capital cost, operating cost, raw material cost, processing cost etc., Various measures of profitability. *Problems solvable analytically*: Minimize the capital cost of cylindrical pressure vessel with flat and closed ends-Optimum thermal insulation thickness for cylindrical pipe, Optimum intermediate concentration and time of reaction for series reaction in batch reactor, Optimum pipe diameter for an incompressible fluid, Minimum work done on two and three-stage compressor for isentropic compression of ideal gas. *Problems solvable numerically*: Optimum reflux ratio for a staged-distillation column, Fitting vapor-liquid equilibrium data using nonlinear regression, optimum design of shell-and-tube heat exchanger, optimization of a thermal cracker using linear programming.

Text Books

1. Edgar T. F., Himmelblau D. M., "Optimisation of Chemical Processes", McGraw Hill.
2. Rao S.S., "Optimization: Theory and Applications", Wiley Eastern.

Reference Books

1. Louis Theodore and Kelly Behan, "Introduction to Optimization for Environmental and Chemical Engineers", CRC press.
2. Rajesh Kumar Arora, "OPTIMIZATION Algorithms and Applications", CRC press
3. Philip D.T. and Ravindran A., "Operations Research", John Wiley.
4. Beightler C.S., Phillips D.T. & Wilde D.J., Foundations of Optimization, Prentice Hall of India
5. Beveridge G.S.G. & Schechter R.S., Optimization: Theory & Practice, McGraw Hill

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Module 1**	**8**
1.1	Scope and hierarchy of optimization.	1
1.2	Statement of an Optimization Problem and its essential features.	1
1.3	Nature and classification of mathematical functions.	1
1.4	Typical chemical engineering applications of optimization. Mathematical modelling of typical chemical engineering optimization problems.	2
1.5	Graphical representation of univariate and bivariate functions (using MATLAB / Python etc.).	1
1.6	Unimodal functions, determination of convexity and concavity of single and multivariate functions.	2
2	**Module 2**	**7**
2.1	*Analytical methods*: Necessary and sufficient conditions for optimum of univariate unconstrained functions.	1
2.2	*Numerical methods*: one dimensional gradient-free search methods (Fixed & accelerated step size,)	1
2.3	*Numerical methods*: Dichotomous search method	1
24	*Numerical methods*: Fibonacci search method	1
2.5	*Numerical methods*: golden-section method and quadratic interpolation)	2
2.6	One dimensional gradient search methods (Newton's method and Quasi-Newton method).	1
3	**Module 3**	**6**
3.1	*Nonlinear programming with equality constraints*: method of direct substitution, ,	1
3.2	*Nonlinear programming with equality constraints*: Lagrange multiplier method	1
3.3	*Nonlinear programming with inequality constraints*: Kuhn-Tucker conditions for local optimality	2
3.4	Complex method,	1
3.5	Rosen's gradient projection method.	1
4	**Module 4**	**7**
4.1	*Unconstrained multivariate optimization problems*: univariate search, Powell's method.	1
4.2	*Constrained multivariate optimization problems*: method of steepest descent	1
4.3	Fletcher-Reeve's conjugate-gradient method	1
4.4	Newton's method	1
4.5	Basic concepts and graphical representation of Linear programming, graphical solution	1

4.6	Simplex method and two-phase simplex method.	2
5	**Module 5**	**7**
5.1	*Economic considerations*	1
5.2	Minimize the capital cost of cylindrical pressure vessel with flat and closed ends, Optimum thermal insulation thickness for cylindrical pipe.	1
5.3	Optimum intermediate concentration and time of reaction for series reaction in batch reactor, Optimum pipe diameter for an incompressible fluid	1
5.4	Minimum work done on two and three-stage compressor for isentropic compression of ideal gas.	1
5.5	*Problems solvable numerically*: Optimum reflux ratio for a staged-distillation column	1
5.6	Fitting vapor-liquid equilibrium data using nonlinear regression, optimum design of shell-and-tube heat exchanger.	1
5.7	optimization of a thermal cracker using linear programming.	1

CHT448	NANOMATERIALS AND NANOTECHNOLOGY	CATEGORY	L	T	P	CREDIT
		PEC	2	1	0	3

Preamble: Nanotechnology has emerged as an important and exciting area in science and engineering. It provides promises in many technological advancements 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: Nil

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	Understand the 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 Bionanotechnology.

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

EIGHTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: CHT448

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

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 1

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 2

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 3

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 4

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 5

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 (7 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 (7 Hrs.)

Synthesis methods - top down and bottom up approaches.

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 SiO_2

Special nano-materials - synthesis, properties and applications – fullerenes, graphene, graphite, carbon nano-tubes, nano wires, nano rods, nanofluids, nanoclusters.

Module 3: Nanocomposites and Bionanotechnology (7 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 (7 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 (7 hours)

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	**Module 1**	**7**
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. Electromagnetic spectrum, particle size and its significance.	2
1.3	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.	1
1.4	Chemistry of nanomaterials - Ionic properties of nanomaterials, electronic phenomenon in nanostructures	2
2	**Module 2**	**7**
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	2
2.3	Synthesis, properties and applications of nanomaterials like gold, silver and different types of nano-oxides like Al2O3, TiO2, ZnO and SiO_2	1
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	1
3	**Module 3**	**7**
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	1
4	**Module 4**	**7**
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)	2
4.2	UV-visible spectroscopy, Raman spectroscopy, Nuclear Magnetic Resonance Spectroscopy (NMR), Fourier Transform Infrared Spectroscopy (FTIR)	2
4.3	X-Ray Diffraction (XRD), Dynamic Light Scattering (DLS)	1
4.4	Thermogravimetric analysis (TGA), Differential Thermal Analysis (DTA), Differential Scanning Calorimetry (DSC)	2
5	**Module 5**	**7**
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	2

CHT458	SAFETY ENGINEERING OF PROCESS PLANTS	CATEGORY	L	T	P	CREDIT
		PEC	2	1	0	3

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

Prerequisite: Nil

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 the chemical engineering fundamentals in the chemical hazards prevention techniques.
CO 3	Understand the physical hazards and human factors in process safety.
CO 4	Develop an understanding about safety practices in industries and emergency planning.
CO 5	Identify various hazards associated with chemical process industries using various techniques and knowledge of risk.

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): Impart the basic concepts of safety in Process Industries.

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

2. Assess the cost of accidents

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

Course Outcome 2 (CO2): Apply the chemical engineering fundamentals in the chemical hazards prevention techniques.

1. List the classification of fire

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

3. Describe BLEVE.

Course Outcome 3(CO3): Analyse the physical hazards and human factors in process safety.

1. List the physical hazards present in a process industry

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

3. Describe the human factors in safety.

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

1. List the safety procedures to be followed in the 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): Identify various hazards associated with chemical process industries using various techniques and knowledge of risk.

1. Explain the HAZOP methodology.

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

EIGHTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: CHT458

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

CHT458 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 1

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 2

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 3

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 about different types of Human errors.

b) Explain the significance of ergonomics in process safety. (7+7=14 marks)

MODULE 4

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) Discuss about the significance of flame arresters in process industries. (4marks)

MODULE 5

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 process safety: (7 Hrs.)

Introduction to process safety: Concept and importance of process safety. Safety in the site selection and lay out. Review of Industrial Accidents- Major Chemical Industry Accidents, Bhopal, Flixborough, SEVESO. Cost of accidents. Material safety data sheet (MSDS). Work permit system, Personal Protective Equipments (PPE).

Regulatory Bodies: - National safety council, OSHA, Loss prevention association, PESO, NEBOSH.

Module 2: Chemical Hazards (8 Hrs.)

Chemical Hazards- Fire triangle, LFL,UFL, Types of fire- Pool fire, jet fire, Flash fire and Fire ball. Fire prevention techniques in process industry. Flammability diagram- construction and application.

Explosion- Deflagration, Detonation, UVCE, BLEVE and Dust explosion. Prevention techniques for explosion.

Toxic release: - Types of exposure, Measure of toxicity, Types of toxic effects. Run away reactions and their mitigation.

Module 3: Process and Plant hazards: (6 Hrs.)

Process and Plant hazards: Physical hazards- Atmospheric contaminants, Sound, Light, Radiation, Pressure, and Temperature. Electrical hazards- electric shock, flash over, lightning Strokes. Mechanical hazards. Environmental hazards.

Human Errors- People Oriented Errors, Situation Oriented errors, System oriented errors. Ergonomics.

Module 4: Prevention techniques for hazards (7 Hrs.)

Prevention techniques for hazards. Hazardous area classification. Safety in transportation of hazardous chemicals by road-HAZCHEM CODE, TREM CARD, Relief system and Detectors. Flame arresters and Flare system.

Hazard rating of chemical plants- Dow fire, explosion and Toxicity index. Chemical exposure index. Emergency planning-onsite and offsite emergency planning, Mock drill.

Module 5: Hazard identification and Risk: (7 Hrs.)

Hazard identification and Risk: HAZOP, Bow tie diagram, Fault tree analysis, failure mode and effect analysis, Event tree analysis, Layer of protection analysis. Examples.

Quantitative Risk Assessment (methodology only), Probit equations, FN curves, Risk-individual risk, societal risk. Safety integrity level (SIL). The concept of inherent safety and Reliability. Security in process industries.

Text/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. Daniel A. Crowl/ Joseph F. Louvar , Chemical Process Safety Fundamentals with applications, Prentice Hall international series, Second edition.
3. K.S.N Raju, Chemical Process Industrial safety, McGraw Hill, 2014.
4. Ralph King, Safety in the Process Industries, Butterworth-Heinemann.
5. R.K.Jain & Sunil S Rao, Industrial Safety, Health and Environment Management Systems, Khanna Publishers, Fourth Edition,2000
6. Encyclopaedia of Occupational Health & Safety, International labour Office, Geneva, 2012
7. Frank P. Lees- "Loss Prevention in Process Industries", Vol.1,2&3,Second Edn, Butterworth-Heinemann.1996
8. Guidelines for Hazard Evaluation Procedure. Centre for Chemical Process Safety.AICHE,1992
9. 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	**Module 1**	**7**
1.1	Concept and importance of process safety, Safety in the site selection and lay out.	2
1.2	Review of Industry Accidents, Major Chemical Industry Accidents Cost of accidents.	2
1.3	Material safety data sheet (MSDS). Work permit system, Personal Protective Equipments (PPE).	2
1.4	Regulatory Bodies: - National safety council, OSHA, Loss prevention association, PESO, NEBOSH.	1
2	**Module 2**	**8**
2.1	Fire triangle, LFL, UFL, Types of fire- Pool fire, jet fire, Flash fire and Fire ball. Fire prevention techniques in process industry. Flammability diagram- construction and application.	4
2.2	Explosion: - Deflagration, Detonation, UVCE, BLEVE and Dust explosion. Prevention techniques for explosion.	2
2.3	Toxic release: - Types of exposure, Measure of toxicity, Types of toxic effects. Run away reactions and their mitigation.	2
3	**Module 3**	**6**
3.1	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	Human Errors- People Oriented Errors, Situation Oriented errors, System oriented errors. Ergonomics.	1
4	**Module 4**	7
4.1	Hazard area classification. Safety in transportation of hazardous chemicals by road	2
4.2	HAZCHEM CODE, TREM CARD Relief system and Detectors. Flame arresters and Flare system	2
4.3	Hazard rating of chemical plants- Dow fire, explosion and Toxicity index. Chemical exposure index.	2
4.4	Emergency planning-onsite and offsite emergency planning, Mock	1

	drill.	
5	**Module 5**	7
5.1	HAZOP, Bow tie diagram, Fault tree analysis, failure mode and effect analysis, Event tree analysis, Layer of protection analysis. Examples.	3
5.2	Quantitative Risk Assessment (methodology only), Probit equations, FN curves, Risk-individual risk, societal risk. Safety integrity level (SIL).	2
5.3	The concept of inherent safety and Reliability. Security in process industries.	2

CHT468	NOVEL SEPARATION TECHNIQUES	CATEGORY	L	T	P	CREDIT
		PEC	2	1	0	3

Preamble: Separation techniques are integral unit operation in most of the chemical, pharmaceutical and other process plants. The separation processes, like, membrane based techniques, and chromatographic separations are gaining importance in plants. The present course is designed to emphasize on these novel separation processes.

Prerequisites: Nil

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

CO1	Summarize the factors influencing the choice of separation techniques.
CO2	Develop models and solutions for membrane separation processes
CO3	Solve problems involving surfactant and adsorption based separation
CO4	Describe the treatment of process liquids by ion exchange process and it's applications.
CO5	Explain the treatment of process liquids by Chromatographic Separations and it's 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											
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	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): Summarize the factors influencing the choice of separation techniques.

1. What are the factors influencing the choice of separation process?
2. Explain inherent separation factor
3. Discuss the solvent properties

Course Outcome 2 (CO2): Develop models and the solutions for membrane separation processes

1. Classify the membrane separation processes
2. Discuss the principle involved in Ultrafiltration
3. Classify models for membrane separation processes

Course Outcome 3 (CO3): Solve problems involving surfactant and adsorption based separation

1. Explain Micro emulsion and Macro emulsion.
2. Discuss the classifications of surfactant based separation techniques
3. Explain the principle of Foam flotation

Course Outcome 4 (CO4): Describe the treatment of process liquids by ion exchange process and it's applications.

1. Explain the principle Ion exchange separation process
2. Explain the applications of Ion exchange process
3. Explain Ion exclusion

Course Outcome 5 (CO5): Explain the treatment of process liquids by Chromatographic Separations and it's applications.

1. List out the different types of chromatography
2. What is the principle of retention theory
3. Comparison of chromatography with other separation techniques.

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Model Question Paper

QP CODE: **PAGES: 2**

Reg No: ______________ **Name: ______________**

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

EIGTH SEMESTER B. TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: CHT468

Max. Marks: 100 Duration: 3 Hours

NOVEL SEPARATION TECHNIQUES

PART – A

Answer All the Questions (10 x 3 = 30)

1. Explain inherent separation factor
2. What are the factors influencing the choice of separation process
3. Classify the various separation processes.
4. What are the advantages of membrane separation processes over conventional separation processes?
5. Enlist the factors affecting membrane performance.
6. Write a note on ultrafiltration.
7. Explain solvent ablation
8. Explain adsorption equilibrium.
9. Discuss the binary ion exchange equilibrium.
10. Explain the principle of chromatographic separation.

PART – B

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

Module 1

11. (a) Discuss the recent advances in separation techniques based on size and surface properties

    (b) Explain the energy requirements of separation processes. **(7+7 = 14 Marks)**

OR

12. (a) Discuss the characteristics and selection of separation process.

    (b) Differentiate the rate based versus equilibrium separation processes

    (7+7 = 14 Marks)

Module 1I

13. (a) What are the experimental techniques used for characterization of membranes ?

    (b) Discuss the working principle, flux equation and applications of ultrafiltration process with neat sketch. **(7+7 = 14 Marks)**

OR

14. A dialysis process is being designed to recover a certain solute from a dilute solution having solute concentration 2.0×10^{-2} kg mol/m^3 through a membrane to a solution having solute

concentration 0.3×10^{-2} kg mol/m^3. The membrane is 1.59×10^{-5} m thick. The distribution coefficient is 0.75; the diffusivity of solute through membrane is 3.5×10^{-11} m^2/s. The mass transfer coefficients in the upstream and downstream are 3.5×10^{-5} m/s and 2.1×10^{-5} m/s, respectively. Calculate: (i) The individual resistance, total resistance and total percent resistance of the two films. (ii) The flux at steady state and the total area in m^2 for a transfer of 0.01 kg mol solute/h. **(14 Marks)**

Module III

15. (a) Discuss the principle and classifications of surfactant based separation process

(b) Differentiate between Micro emulsion and Macro emulsions **(7+7 = 14 Marks)**

OR

16. (a) Explain Adsorptive bubble separations and Ion flotation

(b) Explain surfactants at Inter phases and in bulk **(7+7=14 Marks)**

Module IV

17. Discuss in detail the process principles involved in Pressure Swing Adsorption (PSA) and Temperature Swing Adsorption (TSA) with industrial applications. **(14 Marks)**

OR

18. (a) Explain binary ion exchange equilibrium and Ion movement theory

(b) Explain mass transfer in ion exchange systems. **(7+7=14 Marks)**

Module V

19. Define the following terms in connection with chromatographic separations and give appropriate equations

(a) Partition coefficient , (b) Retention Volume (c) Retention Ratio

d) Capacity factor (e) Separation factor (f) Resolution (g) separation efficiency

(7x2 =14 Marks)

OR

20. (a) Comparison of chromatography with other separation methods.

(b) Discuss different types of chromatography and explain any one in detail

(9+5 = 14 Marks)

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Syllabus

Module 1: Overview of Separation Processes and their Selection (8 Hrs.)

Characteristics and selection of separation process: Importance and variety of separation, economic significance, inherent separation factor, selection, factors influencing the choice of separation process, solvent selection, selection of equipment. Recent advances in separation techniques based on size, surface properties, ionic properties and other special characteristics of substances, Rate based versus equilibrium separation processes, Selection of separation process, Energy requirements of separation processes.

Module 2: Membrane processes (6 Hrs.)

Membrane processes: Introduction, Type and choice of membranes, Plate and frame, tubular, spiral wound and hollow fibre membrane reactors and their relative merits, Membrane filtration, Microfiltration, Nanofiltration, Ultrafiltration, Reverse Osmosis, Dialysis, Models for membrane separations.

Module 3: Surfactant Based Separation Techniques (6 Hrs.)

Surfactant Based Separation Techniques: Basic principles, classifications, Surfactants at Inter phases and in bulk, Foam fractionation, Foam flotation, Adsorptive bubble separations, Ion flotation, Micro emulsion /Macro emulsions, Hydrotopes, Solvent ablation.

Module 4: Adsorption systems (8 hrs)

Adsorption systems: Interacting solutes, Adiabatic adsorbers, velocity effects. Adsorption-Desorption operations: Thermal desorption of gases, Activated carbon solute recovery, Processing liquid using thermal regeneration, Pressure swing and vacuum swing adsorption, Regeneration with purge and desorbent. **Ion exchange:** Basics of Ion exchange, Ion exchange resins, Binary ion exchange equilibrium, Ion movement theory, Applications, Applications without exchange: Ion exclusion, Mass transfer in ion exchange systems.

Module 5: Chromatographic Separations (7Hrs.)

Chromatographic Separations: Introduction, types of chromatography, Elution chromatography: Principles and Retention theory, Band broadening and separation efficiency, Types of chromatography, Large scale elution (cyclic/batch) chromatography, Selective adsorption of biological macromolecules, Simulated countercurrent techniques, Comparison with other separation methods.

Text Books

1. Seader, J D, and Ernest J Henley. *Separation Process Principles*. New York, Wiley, 1998.
2. Marcel Mulder, "Basic Principles of Membrane Technology", 2 Ed., Springer Publications, 2007
3. King C. J.; "Separation Processes"; Tata McGraw–Hill Publishing Co. Ltd., 1982.
4. Wankat, P. C. "Rate- Controlled Separations", Springer, 1994.
5. R W Rousseau, Handbook of Separation Process Technology, John Wiley & Sons (2009)

Reference Books

1. Nunes S P, Peinemann K V, "Membrane Technology in the chemical industry", 2nd Edition, Wiley-VCH, 2006.
2. Rautanbach and Albrecht R., "Membrane Process", John Wiley and Sons.1989.
3. Crespo. J G, Bodekes K W, "Membrane Processes in separation and Purification", Kluwer Academic Publications, Netherland, 1994.
4. Geankoplis C J "Transport processes and Unit Operations", 4th Edition, PHI, New Delhi, 2006.
5. Philip Schweitzer; "Handbook of Separation Techniques for Chemical Engineers", Third Edition, Tata McGraw Hill New York, 1997.

Course Contents and Lecture Schedule:

No.	Details	No. of Lectures
1	**Module 1**	**8**
1.1	Characteristics and selection of separation process	1
1.2	Importance and variety of separation, economic significance	1
1.3	inherent separation factor, selection, factors influencing the choice of separation process	1
1.4	solvent selection, selection of equipment.	1
1.5	Recent advances in separation techniques based on size, surface proper ties, ionic properties and other special characteristics of substances,	1
1.6	Rate based versus equilibrium separation processes,	1
1.7	Selection of separation process, Energy requirements of separation processes.	2
2	**Module 2**	**6**
2.1	Introduction, Type and choice of membranes	1
2.2	Plate and frame, tubular, spiral wound and hollow fibre membrane reactors and their relative merits	1
2.3	Membrane filtration, Microfiltration, Nano filtration	1
2.4	Ultrafiltration, Reverse Osmosis, Dialysis	2
2.5	Models for membrane separations.	1
3	**Module 3**	**6**
3.1	Basic principles, classifications, Surfactants at Inter phases and in bulk, Foam fractionation	2
3.2	Foam flotation, Adsorptive bubble separations,	2
3.3	Ion flotation, Micro emulsion /Macro emulsions	1
3.4	Hydro topes, Solvent ablation	1
4	**Module 4**	**8**
4.1	Interacting solutes, Adiabatic adsorbers,	1
4.2	velocity effects. Adsorption-Desorption operations: Thermal desorption of gases,	1
4.3	Activated carbon solute recovery, Processing liquid using thermal regeneration,	2
4.4	Pressure swing and vacuum swing adsorption, Regeneration with purge and desorbent.	2
4.5	Basics of Ion exchange, Ion exchange resins, Binary ion exchange equilibrium, Ion movement theory,	1
4.6	Applications, Applications without exchange: Ion exclusion, Mass transfer in ion exchange systems.	1
5	**Module 5**	**7**
5.1	Introduction, types of chromatography, Elution chromatography:	1
5.2	Principles and Retention theory, Band broadening and separation efficiency	2
5.3	Types of chromatography, Large scale elution (cyclic/batch) chromatography	2

5.4	Selective adsorption of biological macromolecules,	1
5.5	Simulated countercurrent techniques, Comparison with other separation methods.	1

CHT478	FUEL CELL TECHNOLOGY	CATEGORY	L	T	P	CREDIT
		PEC	2	1	0	3

Preamble: One of the most critical challenges facing the world is the development of clean, reliable, and efficient energy conversion processes. Because the standard of living of virtually all nations is directly related to per capita energy consumption, the demand for energy will inevitably increase. One of the most promising near-term technologies are those based on fuel cells, which convert chemical energy into electrical energy with higher efficiencies and far fewer environmental effects than other options. This course is intended to provide an insight into the fuel cell and focuses on developments made in the area and the challenges facing in its wide practical applications. The course also brings an overview on future prospects in the development and application of fuel cell.

Prerequisite: Thermodynamics, Reaction Engineering, Mass Transfer Operations

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

CO 1	Explain the fundamentals of electrochemistry, thermodynamics, fluid mechanics, and heat and mass transfer, components of fuel cells and fuel cell systems.
CO 2	Illustrate various types of fuel cells and compare it with conventional systems.
CO 3	Explain the significance of fuel cell technology in the new global energy scenario.
CO 4	Design and explain fuel cell stack and fuel cell systems.
CO 5	Distinguish the expectances of hydrogen as a fuel and energy vector in the context of renewable energy.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3				2	2					3
CO 2	3					2	2					2
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	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): Explain the fundamentals of electrochemistry, thermodynamics, fluid mechanics, and heat and mass transfer, components of fuel cells and fuel cell systems.

1. Outline the major functions of bipolar plates in a PEM fuel cell. Illustrate how material selection is carried out for the gas diffusion layer to meet its major functions.
2. A direct methanol fuel cell uses methanol (CH3OH) as fuel instead of hydrogen:

$$CH_3OH + {}^3/_2\, O_2 \rightarrow CO_2 + 2H_2O_{(liq)}$$

Calculate the standard-state reversible potential for a direct methanol fuel cell and standard state Gibbs free energy change of the reaction. Also calculate the reversible voltage of the fuel cell operating at a temperature 350 K. The entropy of the reaction at 350 K is given - 82 J/(mol K). The standard state potential of half reaction is given below

$$CO_2 + 6H^+ + 6\bar{e} \leftrightarrow CH_3OH + H_2O \qquad E^0 = +0.03\ V$$

$$O_2 + 4H^+ + 4\bar{e} \leftrightarrow 2H_2O \qquad E^0 = +1.229\ V$$

Course Outcome 2 (CO2): Illustrate various types of fuel cells and compare it with conventional systems.

1. Compare fuel cell with batteries
2. Explain principle, working with neat sketch of PAFC.

Course Outcome 3(CO3): Defend the significance of fuel cell technology in the new global energy scenario.

1. Explain the significance of fuel cell technology in the new global energy scenario.

Course Outcome 4 (CO4): Design and explain fuel cell stack and fuel cell systems.

1. Design a hydrogen – air fuel cell stack to produce a power output of 10 kW. Fuel cell is used for power backup having voltage 24 V. Following data are provided for the design.

Parameter	**Unit**	**Value**
Fuel	--	Hydrogen
Oxidant	--	Air
Temperature	K	350
Pressure	kPa	101.3
Gas constant, R	J/(mol K)	8.314
Transfer coefficient, α	--	1
No. of electrons involved, n	--	2
Faraday's constant, F	C/mol	96485
Current loss, i_{loss}	A/cm^2	0.0015
Reference exchange current density, i_o	A/cm^2	$2.5x10^{-6}$
Limiting current density, i_L	A/cm^2	1.5
Internal resistance, R_i	$Ohm\text{-}cm^2$	0.125

Course Outcome 5 (CO5): Distinguish the expectances of hydrogen as a fuel and energy vector in the context of renewable energy.

1. List the unique features that make hydrogen an ideal energy carrier.

Model Question Paper

QP CODE: **PAGES: 3**

Reg No: ______________ **Name:** __________________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

EIGHTH SEMESTER B. TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: CHT 478

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

FUEL CELL TECHNOLOGY

PART – A

Answer All the Questions (10 x 3 = 30)

1. Compare fuel cell with batteries
2. Write the chemical reactions involved in PEMFC and SOFC
3. Explain activation overvoltage.
4. Describe the effect of concentration on rate of reaction.
5. Define ohmic resistance
6. Define limiting current density
7. Define fuel cell stack.
8. Explain fuel cell stack clamping.
9. Explain autothermal reforming.
10. Write the chemical reactions involved in the partial oxidation and steam reforming.

PART – B

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

Module 1

11	a)	Explain the significance of fuel cell technology in the new global energy scenario.	(7)
	b)	Explain principle, working with neat sketch of PAFC.	(7)

Or

12		Outline the major functions of bipolar plates in a PEM fuel cell. Illustrate how material selection is carried out for the gas diffusion layer to meet its major functions.	(14)

Module 2

13	a)	Derive Tafel equation.	(8)
	b)	Derive an expression to show the relation between Gibbs free energy and electrical work.	(6)

Or

14 a) A direct methanol fuel cell uses methanol (CH3OH) as fuel instead of hydrogen: (8)

$$CH_3OH + {}^3\!/_2\,O_2 \rightarrow CO_2 + 2H_2O_{(liq)}$$

Calculate the standard-state reversible potential for a direct methanol fuel cell and standard state Gibbs free energy change of the reaction. Also calculate the reversible voltage of the fuel cell operating at a temperature 350 K. The entropy of the reaction at 350 K is given - 82 J/(mol K). The standard state potential of half reaction is given below

$$CO_2 + 6H^+ + 6\bar{e} \leftrightarrow CH_3OH + H_2O \qquad E^O = +0.03\ V$$
$$O_2 + 4H^+ + 4\bar{e} \leftrightarrow 2H_2O \qquad E^O = +1.229\ V$$

b) Illustrate how increase in temperature and increase in reactant concentration increases reaction rate in a fuel cell. (6)

Module 3

15 a) Consider the two fuel cells, Fuel cell-1 (Area 8 cm^2 and resistance 0.15 Ω) and Fuel cell-2 (Area 20 cm^2 and resistance 0.1 Ω). Determine which fuel cell subject to larger ohmic voltage loss, at a current density of 3 A/cm^2. (8)

b) Illustrate how concentration affects Nernst voltage. (6)

Or

16 a) Explain the ionic conduction in the aqueous electrolytes and ceramic electrolyte. (8)

b) List the requirements that an electrolyte should meet in a fuel cell. (6)

Module 4

17 a) Explain the heat removal methods in the fuel cell (7)

b) Explain the polarization curve as a diagnostic tool for fuel cell. (7)

Or

18 Design a hydrogen – air fuel cell stack to produce a power output of 10 kW. Fuel cell is used for power backup having voltage 24 V. Following data are provided for the design. (14)

Parameter	**Unit**	**Value**
Fuel	--	Hydrogen
Oxidant	--	Air
Temperature	K	350
Pressure	kPa	101.3
Gas constant, R	J/(mol K)	8.314
Transfer coefficient, α	--	1
No. of electrons involved, n	--	2
Faraday's constant, F	C/mol	96485
Current loss, i_{loss}	A/cm^2	0.0015
Reference exchange current density, i_o	A/cm^2	2.5×10^{-6}
Limiting current density, i_L	A/cm^2	1.5
Internal resistance, R_i	$Ohm\text{-}cm^2$	0.125

Module 5

19 a) Describe oxygen and hydrogen supply system in a $H_2 – O_2$ fuel cell system. (7)

b) Discuss the humidification system for PEM fuel cell. (7)

Or

20 a) List the unique features that make hydrogen an ideal energy carrier. (7)

b) Discuss various technologies for storing hydrogen. (7)

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Syllabus

Module 1: Introduction (7 Hrs.)

Introduction: Fuel Cell, Brief History of fuel cells, Fuel Cell and conventional processes – comparison, Types of Fuel Cells Application scenarios, Advantages and disadvantages, Energy & power relations, units, Working of a PEM fuel Cell, Major Cell Components, Material Properties, Processes and Operating Conditions of PEMFC.

Module 2: Thermodynamics and Reaction Kinetics (7 Hrs.)

Thermodynamics: Gibb's free energy -Work potential of fuel, Reversible voltage - NERNST Equation, Voltage and P, T and concentration dependence – examples, Faraday's Laws, Efficiency: thermodynamic, voltage and fuel.

Reaction Kinetics: Electrochemical reaction fundamentals, electrode kinetics, Charge transfer and activations energy, Exchange current density - slow and fast reactions, Potential and equilibrium - galvanic potential, Reaction rate and potential - Butler Volmer equation & Tafel equation, Exchange Currents and Electrocatalysis: How to Improve Kinetic Performance, Electrode design basics.

Module 3: Charge and Mass Transport (7 Hrs.)

Charge and Mass Transport: Charge transport resistances, voltage losses, Ionic and electronic conductivities, Ionic conduction in different FC electrolytes: Aqueous, polymeric and ceramic, Diffusive transport & voltage loss: Limiting current density, Nernstian and kinetic effect, Convective transport: flow channels, gas diffusion / porous layer, gas velocity, pressure.

Module 4: Stack Design and Fuel Cell Diagnostics (7 Hrs.)

Stack Design: Sizing of a Fuel Cell Stack, Stack Configuration, Uniform distribution of Reactants, Heat removal, Stack Clamping.

Fuel Cell Diagnostics: Polarization Curve, Current Interrupt, AC Impedance Spectroscopy, Pressure drop as a diagnostic tool.

Module 5: Fuel Cell System Design and Hydrogen Economy (7 Hrs.)

Fuel Cell System Design: Hydrogen-Oxygen Systems, Hydrogen-Air Systems, Fuel Cell Systems with Fuel Processor, System Efficiency.

Fuel Cells and Hydrogen Economy: Hydrogen Energy Systems, Hydrogen Energy Technologies, Transition to Hydrogen Economy.

Text Books

1. Ryan P. O'Hayre, Suk-Won Cha, Whitney Colella & Fritz B. Printz, Fuel Cell Fundamentals, John Wiley & Sons, Inc., New Jersey, 2006
2. Frano Barbir. PEM Fuel Cells: Theory and Practice. Elsevier, 2005

Reference Books

1. Vielstich, W, Gasteiger, H. A. Lamm, A. (Eds):Handbook of Fuel Cells Fundamentals, Technology and Applications. John Wiely & Sons Ltd: NY, 2003; Vols1-4
2. Fuel Cell Handbook,7the Edn., EG & G Technical Services, Nov 2004
3. Hordeski, M. F. Alternative Fuels: The Future of Hydrogen, The Fairmont Press: Lilburn, GA, 2007.
4. Kordesch, K.; Simader, G. Fuel Cells and Their Applications. VCH: 1996
5. Larminie, J.; Dicks, A. Fuel Cell Systems Explained. John Wiely & Sons Ltd: Chichester, 1999.
6. Andreas Zuttel; Andreas Borgschulte; Louis Schdaptach, Hydrogen as a future energy carrier, Wiley-VCH Verlag GmbH & Co., KGaA, Weinheim, 2008

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Module 1**	**7**
1.1	**Introduction:** Fuel Cell, Brief History of fuel cells, Fuel Cell and conventional processes – comparison.	1
1.2	Types of Fuel Cells	1
1.3	Application scenarios, Advantages and disadvantages.	1
1.4	Energy & power relations, units	1
1.5	Working of a PEM fuel Cell	1
1.6	Major Cell Components, Material Properties, Processes and Operating Conditions of PEMFC.	2
2	**Module 2**	**7**
2.1	Gibb's free energy-Work potential of fuel, Reversible voltage - NERNST Equation, Voltage and P, T and concentration dependence – examples.	2
2.2	Faraday's Laws, Efficiency: thermodynamic, voltage and fuel.	1
2.3	Electrochemical reaction fundamentals, electrode kinetics, Charge transfer and activations energy	1
24	Exchange current density - slow and fast reactions, Potential and equilibrium - galvanic potential	1

2.5	Reaction rate and potential - Butler Volmer equation & Tafel equation, Exchange Currents and Electrocatalysis: How to Improve Kinetic Performance, Electrode design basics	2
3	**Module 3**	**7**
3.1	Charge transport resistances, voltage losses, Ionic and electronic conductivities	2
3.2	Ionic conduction in different FC electrolytes: aqueous, polymeric and ceramic	1
3.3	Diffusive transport & voltage loss: Limiting current density, Nernstian and kinetic effect	2
3.4	Convective transport: flow channels, gas diffusion/porous layer, gas velocity, pressure	2
4	**Module 4**	**7**
4.1	Sizing of a Fuel Cell Stack	2
4.2	Stack Configuration, Uniform distribution of Reactants	2
4.3	Heat removal, Stack Clamping	1
4.4	Polarization Curve, Current Interrupt	1
4.5	AC Impedance Spectroscopy, Pressure drop as a diagnostic tool	1
5	**Module 5**	**7**
5.1	Hydrogen-Oxygen Fuel Cell Systems	1
5.2	Hydrogen-Air Fuel Cell Systems	1
5.3	Fuel Cell Systems with Fuel Processor	1
5.4	System Efficiency	1
5.5	Hydrogen Energy Systems	1
5.6	Hydrogen Energy Technologies	1
5.7	Transition to Hydrogen Economy	1

SEMESTER VIII

MINOR

CHD482	MINI PROJECT	CATEGORY	L	T	P	CREDIT
		PWS	0	0	3	4

Preamble: Mini 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;

CO1	Identify and synthesize problems and propose solutions to them.
CO2	Prepare work plan and liaison with the team in completing as per schedule.
CO3	Validate the above solutions by theoretical calculations and through experimental
CO4	Write technical reports and develop proper communication skills.
CO5	Present the data and defend ideas.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3					3	3		2
CO2	3			3				3	3	3	3	
CO3	3	3	3	3	3					3		
CO4					3			3	3	3		1
CO5	3	3	3	3				3		3	3	1

*1-slight/low mapping, 2- moderate/medium mapping, 3-substantial/high mapping

Continuous Internal Evaluation Pattern:

Sl. No.	Level of Evaluation	Marks
1	Interim evaluation by the committee	**20**
2	Project Guide	**30**
3	Final Seminar evaluation by the committee	**30**
4	The report evaluated by the evaluation committee	**20**
	Total	**100**
	Minimum required to pass	**50**

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

SEMESTER VIII

HONOURS

CHD496	MINI PROJECT	CATEGORY	L	T	P	CREDIT
		PWS	0	0	3	4

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CO1	3	3	3	3					3	3		2
CO2	3			3				3	3	3	3	
CO3	3	3	3	3	3					3		
CO4					3			3	3	3		1
CO5	3	3	3	3				3		3	3	1

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