SEMESTER V

CHT 301	MASS TRANSFER OPERATIONS -I	CATEGORY	L	T	P	CREDIT
		PCC	3	1	0	4

Preamble: The analysis of the phenomena of mass transfer is important in engineering design applications. The objective of this course is to study the principles of mass transfer and their application to separation and purification processes. The course integrates fluid dynamics and thermodynamics and proceeds to develop rate expressions for mass transfer in gases, liquids and solids. This course also explains how to solve engineering problems involving different mass transfer operations like absorption, drying, adsorption, humidification and crystallization processes.

Prerequisite: Basic knowledge in Chemical Process Principles and Fluid and Particle Mechanics

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

CO 1	Analyse fundamentals of mass transfer operations and estimate diffusion coefficients
CO 2	Summarize interface mass transfer and concepts of mass transfer coefficients
CO 3	Differentiate among different types of equipments for mass transfer operations
CO 4	Analyse and design tray and packed columns of gas liquid contacting equipments
CO 5	Analyse and design humidification and adsorption systems
CO 6	Analyse and design drying and crystallization systems.

Mapping of course outcomes with program outcomes

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

Assessment Pattern

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

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

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

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

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Course Level Assessment Questions

Course Outcome 1 (CO1): Analyse fundamentals of mass transfer operations and estimate diffusion coefficients

1. Show that $D_{AB} = D_{BA}$ for a binary mixture

2. State and explain Film theory of mass transfer

3. Derive the equation for steady state diffusion in multi component mixtures

Course Outcome 2 (CO2): Summarize interface mass transfer and concepts of mass transfer coefficients

1. Define mass transfer coefficient

2. Derive the relationship between overall and individual mass transfer coefficient

3. Find out the relationship between F- type and k- type mass transfer coefficient

Course Outcome 3(CO3): Differentiate among different types of equipments for mass transfer operations

1. Compare tray tower and packed tower

2. Describe Flooding in packed bed absorption column

3. With a neat sketch describe venturi scrubbers

Course Outcome 4 (CO4): Analyse and design tray and packed columns of gas liquid contacting equipments

1. With neat sketch, describe the constructional features and design constraints of a packed tower.

2. Derive the equation for operating curve for a counter current absorption tower and draw graphs for absorption and stripping

3. 1000kg/hr acetone air mixture containing 2mole% acetone is admitted into a continuous counter current absorber operating at atmospheric pressure and at a constant temperature of 27^0C. It is scrubbed with pure water at a rate of 25% more than the minimum required such that 90% of acetone from the gas phase is absorbed. The equilibrium relationship is given by the equation y = 2.53x where x and y are mole fraction. Given: H_{tG} = 0.353m, H_{tL} = 0.323m. Gas mixture can be assumed dilute. Calculate the height of the tower.

Course Outcome 5 (CO5): Analyse and design humidification and adsorption systems

1. Compare different types of cooling towers and derive the height of the cooling tower using transfer units

2. Explain adsorption isotherm and application of Freundlich Equation to a single stage adsorption process.

3. Equilibrium adsorption for de-colourisation is represented by $Y = 0.003X^2$ where X is kg of colour / kg of adsorbent and Y is kg of colour / kg of colour carrier. Calculate the % removal of colour if 50 kg of colour carrying material containing 1 part of colour per 3 parts of carrier is treated with (i) 15 kg adsorbent in a single stage operation (ii) Using 7.5 kg adsorbent in each stage of two stages cross current unit.

Course Outcome 6 (CO6): Analyse and design drying and crystallization systems

1. Obtain an expression to determine the drying time needed to dry a substance possessing constant rate drying.

2. A crystallizer is charged with 7500kg of aqueous solution at 104^0C containing 30% by weight of Na_2SO_4. The solution is then cooled to 20^0C. During this operation 5% of the original water is lost by evaporation. Glauber salt crystallizes and the solubility at 20^0C is 19.4gm of Na_2SO_4 / 100gm of water. Find the weight of (i) Water lost by evaporation (ii) Crystals formed (iii) Mother liquor leaving.

3. A wet solid is dried from 40 % moisture to 8% moisture in 4 hrs. How long will it take to dry the material to 5% moisture under the same drying conditions. Equilibrium moisture content 4% and critical moisture content of the material was 15% (moisture content in wet basis).

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Model Question Paper

QP CODE: **PAGES: 3**

Reg No: ______________ **Name: ______________**

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIFTH SEMESTER B. TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: CHT301

Max. Marks: 100 Duration: 3 Hours

MASS TRANSFER OPERATIONS - I

PART – A

Answer All the Questions (10 x 3 = 30)

1. State and explain Fick's law of molecular diffusion.
2. Derive the equation for mass transfer coefficient.
3. Explain characteristics of packing materials using in packed columns.
4. Explain flooding and weeping a tray column
5. Explain HTU and NTU
6. Differentiate between physical adsorption and chemisorption
7. What are the different cooling towers are available in industries
8. Explain the principle of wet bulb thermometry
9. Explain application of drying
10. Explain different methods of achieving super saturation.

PART – B

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

Module 1

11 a) State and explain Film theory of mass transfer.

b) Consider two cases for a binary mixture of ideal gases A and B under steady state conditions. In case 1 the diffusion of A occurs through non-diffusing B. in case 2 equimolal counter diffusion of A and B occurs. In both the cases the total pressure is 100 kPa and the partial pressure of A at two points separated at a distance of 10mm are 10 kPa and 5 kPa. Assume that Fick's law of molecular diffusion is applicable. What is the ratio of molar flux of A in case 1 to that in case 2? **(4+10 = 14 marks)**

OR

12 a) Derive the Reynolds analogy starting from fundamental transport equation for momentum, heat and mass. corresponding numbers in heat transfer

b) Diffusivity of toluene is measured by Stefan's method. A vertical glass tube of 3 mm diameter is filled with toluene to a depth of 19mm from top open end. After 275 hours at 37^0C and 1atm. total pressure the level has fallen to 79 mm. from top. Density of toluene is 850 kg/m^3 and Vapour Pressure 37^0C is 57.3 mm Hg Calculate the diffusivity of Toluene in air. **(7+7= 14 marks)**

Module 2

13 a) Explain the principle and working of a venturi scrubber and mention its industrial applications

b) With neat sketch, describe the constructional features and design constraints of a packed tower. **(6+8=14 marks)**

OR

14 a) With neat sketch, describe the constructional features of a tray tower.

b) Explain with neat sketches the different types of packings and packing materials used. **(7+7=14 marks)**

Module 3

15 a) Derive the material balance equation for a gas liquid absorber operating under counter. current flow condition. Using this expression, explain how you will determine the minimum gas liquid ratio

b) Wash oil containing 0.007 kg hexane/kg oil is used in a counter current packed column absorber to scrub a feed gas stream containing 0.09 kg hexane/kg hexane free gas mixture. The outlet gas stream contains 0.001 kg hexane/kg hexane free gas mixture. Determine the height of packed section required to treat 1000 kg/(hr)(m2 of empty tower cross section) of hexane free gas mixture. The equilibrium relation may be taken as Y=1.5 X where Y and X are solute/non-solute mole ratio in gas phase and liquid phase respectively. The overall coefficient Kya may be taken as 350 kg/(hr) (m3) (unit gradient of y). The feed rate of hexane free wash oil is 5000 kg/(hr)(m2). **(6+8=14 marks)**

OR

16 a) Define Murphree stage efficiency

b) Derive Kremser equation for the determination of number of transfer units and state the assumptions used **(6+8=14 marks)**

Module 4

17 a) Explain adsorption wave and break through curve

b) Discuss the nature of adsorbents

c) Explain the principle of wet bulb thermometry and obtain an expression for wet bulb depression. **(4+4+6=14 marks)**

OR

18 a) Discuss briefly on adiabatic saturation curve

b) One litre flask is containing air and acetone at 1atm and 303K with a relative humidity of 35% after 2gm of fresh activated carbon is introduced and flask is sealed Compute the final vapour composition and final pressure neglecting adsorption of air. Vapour pressure of acetone at 30^0C is 283mm Hg.

Equilibrium data:

gm adsorbed/gm carbon	0	0.1	0.2	0.3	0.35
Partial pressure of acetone, mm Hg	0	2	12	42	92

(4+10=14 marks)

Module 5

19 a) Define: bound moisture, unbound moisture and free moisture

b) A wet solid is dried from 35 % moisture to 10% moisture in 5 hrs. How long will it take to dry the material to 6% moisture under the same drying conditions. Equilibrium moisture content 4% and critical moisture content of the material was 14% (moisture content in wet basis) **(6+8=14 marks)**

OR

20 a) Explain Mier's supersaturation theory

b) 1000kg of a 25% aqueous solution of Na_2CO_3 is slowly cooled to 20^0C.During cooling 10% water originally present evaporates. The crystal is $Na_2CO_3.10H_2O$. If the solubility of anhydrous Na_2CO_3 at 20^0C is 21.5kg/100kg of water, what weight of salt crystallizes out? **(5+9=14 marks)**

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Syllabus

Module 1 (10 Hr)

Molecular diffusion - mass fluxes J_A and N_A - Fick's law - diffusivity and estimation - steady state diffusion of A through stagnant B and equimolar counter diffusion in binary gases, liquids and multi component gas mixtures. Mass transfer coefficients, dimensionless groups - analogy between mass, heat and momentum transfer. Basic concepts and assumptions involved in theories of mass transfer: penetration and surface renewal theories - interphase mass transfer - equilibrium - diffusion between phases - two-film theory - local and overall k-type coefficients.

Module 2 (7 Hr)

Gas-Liquid contacting equipments for mass transfer operations - single stage and multistage contact , tray towers, tray types and general features of tray designs (qualitative treatment), continuous contact equipment, wetted wall columns, venturi scrubbers, packed columns, packing materials and characteristics, general constructional details of packed columns, Factors affecting column performance-flooding, priming, coning, weeping, loading etc, comparison between plate and packed columns.

Module 3 (10 Hr)

Gas absorption - Solubility of gases in liquid, choice of solvent, Material balance in counter current and co-current absorption and stripping, L/G ratio, Minimum gas liquid ratio, Multistage operation, number of plates by graphical construction, Kremser equation, tray efficiency, design of packed columns, transfer unit and general graphical method, dilute solutions and simplified design methods

Module 4 (10 Hr)

Humidification and dehumidification, Use of humidity chart to find properties of air, Lewis relation, water cooling with air, types of cooling towers, Design of cooling tower, spray chambers for air humidification, principles of gas dehumidification.

Adsorption, types of adsorption, properties of adsorbents, adsorption isotherm for single gases, vapours and dilute liquid solutions, Adsorption isotherms –Freundlich and Langmuir, Fixed bed adsorption, adsorption wave, rate of adsorption and breakthrough curve.

Module 5 (8 Hr)

Drying, equilibrium, bound and unbound moisture content, batch drying, rate of drying, mechanism of moisture movement, continuous drying, parallel and counter current, material and enthalpy balances, classification of industrial dryers for batch and continuous drying.

Crystallization, principles of crystallization, purity, yield, energy requirements, super saturation, nucleation-primary and secondary nucleation, growth of crystals-delta –L law, Ostwald ripening, crystallisation equipments- Classification of crystallizers, working and schematic diagram of forced circulation, draft tube baffled and Oslo crystallizers, MSMPR

Text Books:

1. Treybal R.E., Mass Transfer Operations, McGraw Hill.
2. Binay K Dutta, Principles of Mass Transfer & Separation Processes, PHI Learning Private Limited.

Reference Books:

1. K.V. Narayanan and B. Lakshmikutty. Mass Transfer-Theory and Applications, CBS Publishers.
2. N. Anantharaman and K.M.Meera Sheriffa Begum, Mass Transfer-Theory and Practice, PHI Learning Private Limited (2011) New Delhi.
3. Welty J.R., Wilson R.E. & Wicks C.E., Fundamentals of Momentum Heat and Mass Transfer, John Wiley
4. Foust A.S. et. al., Principles of Unit Operations, John Wiley
5. McCabe W.L., Smith J.C. & Harriot P., Unit Operations in Chemical Engineering, McGraw Hill.
6. Seader J.D.& Henley E.J Separation Process Principles, John Wiley & Sons
7. Coulson J.M. & Richardson J.F., Chemical Engineering, Vol. II, ELBS, Pergamon

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Course Contents and Lecture Schedule:

No.	Details	No. of Lectures
1	**Module 1**	**10**
1.1	Molecular diffusion - mass fluxes JA and NA - Fick's law -	1
1.2	Diffusivity and estimation -	1
1.3	Steady state diffusion of A through stagnant B and equimolar counter diffusion in binary gases,	1
1.4	Liquids and multi component gas mixtures. Mass transfer coefficients,	2
1.5	Dimensionless groups - analogy between mass, heat and momentum transfer.	1
1.6	Basic concepts and assumptions involved in theories of mass transfer: penetration and surface renewal theories	1
1.7	Interphase mass transfer - equilibrium - diffusion between phases	1
1.8	Two-film theory - local and overall k-type coefficients	2
2	**Module 2**	**7**
2.1	Gas-Liquid contacting equipments for mass transfer operations - single stage and multistage contact	1
2.2	Tray towers, tray types and general features of tray designs (qualitative treatment)	2
2.3	Wetted wall columns continuous contact equipment	1
2.4	Venturi scrubbers	1
2.5	Packed columns, packing materials and characteristics, general constructional details of packed columns	1
2.6	Factors affecting column performance-flooding, priming, coning, weeping, loading etc, comparison between plate and packed columns.	1
3	**Module 3**	**10**
3.1	Gas absorption - Solubility of gases in liquid, choice of solvent	1
3.2	Material balance in counter current and concurrent absorption and stripping	1
3.3	L/G ratio, minimum gas liquid ratio	1
3.4	Multistage operation number of plates by graphical construction, , tray efficiency,	1
3.5	Kremser equation	2
3.6	Design of packed columns, transfer unit and general graphical method	2
3.7	Dilute solutions and simplified design methods	2
4	**Module 4**	**10**
4.1	Humidification and dehumidification,	1
4.2	Use of humidity chart to find properties of air	1
4.3	Lewis relation, water cooling with air	1
4.4	Types of cooling towers, design of cooling tower	1
4.5	Spray chambers for air humidification, principles of gas	1

	dehumidification	
4.6	Adsorption, types of adsorption, properties of adsorbents,	1
4.7	Adsorption isotherm for single gases, vapours and dilute liquid solutions, Adsorption isotherms –Freundlich and Langmuir	2
4.8	Fixed bed adsorption, adsorption wave, rate of adsorption and breakthrough curve.	2
5	**Module 5**	**8**
5.1	Drying, equilibrium, bound and unbound moisture content, batch drying	1
5.2	Rate of drying, mechanism of moisture movement	1
5.3	Continuous drying, parallel and counter current, material and enthalpy balances, classification of industrial dryers for batch and continuous drying.	2
5.4	Crystallization, principles of crystallization, purity, yield, energy requirements	1
5.5	Super saturation, nucleation-primary and secondary nucleation, growth of crystals- delta–L law, Ostwald ripening	1
5.6	Crystallisation equipments- Classification of crystallizers, working and schematic diagram of forced circulation, draft tube baffled and Oslo crystallizers, MSMPR	2

CHT303	ENVIRONMENTAL ENGINEERING	CATEGORY	L	T	P	CREDIT
		PCC	3	1	0	4

Preamble: This course is indented to give fundamental understanding on the impact of chemical process industries on the environment and its remedial measures. Different pollution management strategies are discussed for addressing various modes of pollution.

Prerequisite: NIL

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

CO 1	Explain the environmental legislation and regulation aimed at protecting the environment from harmful actions.
CO 2	Explain the different types of treatment processes for drinking water, municipal water, boiler feed water and saline water.
CO 3	Interpret primary, secondary and tertiary treatment methods used for wastewater treatment.
CO 4	Compare aerobic and anaerobic wastewater treatment methods.
CO 5	Select suitable methods for treatment and disposal of sludge, industrial and hazardous waste.
CO 6	Identify the sources of air and noise pollution and select suitable control methods.

Mapping of course outcomes with program outcomes

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

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	20
Understand	20	20	20
Apply	20	20	40
Analyse			20

Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks

Continuous Assessment Test (2 numbers) : 25 marks

Assignment/Quiz/Course project : 15 marks

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

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. What are the important legislations and standards regarding water?
2. Explain the important legislations and standards regarding air.
3. How are the pollutants classified? Explain.

Course Outcome 2 (CO2):

1. Explain the precipitation processes used for water treatment?
2. Explain lime soda softening with relevant equations.
3. What are the methods used for boiler feed water treatment?

Course Outcome 3(CO3):

1. What are the factors to be considered in the design of a grit chamber?
2. Explain the working of an activated sludge process with a neat sketch.
3. What are the various disinfection methods for water?

Course Outcome 4 (CO4):

1. Explain suspended growth and attached growth processes. With a neat sketch describe the working of rotating biological contactors.
2. Explain the steps involved in the conversion of organic matter to biogas in an anaerobic process.
3. With a neat sketch explain the working of an up-flow anaerobic sludge blanket reactor.

Course Outcome 5 (CO5):

1. Differentiate between windrow and aerated static pile composting with neat sketches.
2. Describe the working of dissolved air flotation unit for sludge thickening.
3. Write a note on classification of solid waste. Explain the working of an incinerator.

Course Outcome 6 (CO6):

1. Explain the global effects of air pollution.
2. Describe the working of a bag filter for air pollution control.
3. What are the various sources of noise pollution? Explain various noise pollution control measures.

Model Question paper

QP CODE: PAGES:

Reg No:………… Name :………….

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIFTH SEMESTER B. TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: CHT 303

Max.Marks:100 Duration: 3 Hours

ENVIRONMENTAL ENGINEERING

(2019-Scheme)

PART A

(Answer all questions, each question carries 3 marks)

1. Write the important legislations and standards regarding water and air.
2. Differentiate temporary and permanent hardness? Explain the removal of both types of hardness.
3. Describe the factors to be considered in the design of a grit chamber.
4. Explain the working of trickling filters with a neat figure.
5. With neat sketch explain break point chlorination.
6. Explain the working of an anaerobic sludge digester.
7. Discuss about the classification of hazardous waste.
8. Explain air pollution meteorology.
9. Explain the working of an electrostatic precipitator.
10. Discuss about the sources and effects of noise pollution.

PART B

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

MODULE-I

11. a) Write in detail about the biological parameters regarding wastewater? (5)
 b) Explain the sampling methods used to determine BOD, COD, DO and TOC (9)
12. a) Explain any two precipitation processes used in water treatment? (10)
 b) Describe various physical characteristics of wastewater. (4)

MODULE-II

13. a) Discuss about the different types of settling? (5)
 b) Explain the primary treatment methods used for wastewater treatment (6)
 c) What are the different types of sedimentation tanks (9)
14. a) With neat figure explain the working of aerobic fluidised bed bioreactors. (7)
 b) Distinguish between the methods used to treat oily matter and finely divided suspended solids from wastewater? (7)

MODULE-III

15. a) Explain in detail the various methods for sludge thickening. (10)
 b) Describe the working of anaerobic sludge digester. (4)
16. a) With a neat figure, explain the treatment methods of pulp and paper mill waste. (7)
 b) Explain in detail about the treatment methods for hazardous waste? (7)

MODULE-IV

17. a) Describe air pollution sampling and analysis. (7)

    b) Explain the factors involved in the meteorological phenomena on air quality. (7)

18. Classify air pollutants. Explain in detail the sources of air pollution and their effects. (14)

MODULE-V

19. a) Describe the advantages and disadvantages of electrostatic precipitator. (7)

    b) Explain the characteristics of fabric and fibre used in the fabric filters. (7)

20. Describe the working of any four methods for gaseous emission control. (14)

Syllabus

Module 1: Introduction to Environmental Engineering-Water and Wastewater Treatment (9 Hours)

Introduction to environmental engineering–environmental legislation and regulation-water quality standards-Water treatment–precipitation processes-alum treatment and lime soda softening, municipal water conditioning-ion exchange processes, boiler feed water treatment–desalination. Sources and classification of wastewater- Types of water pollutants and their effects- Wastewater sampling, preservation and analysis- Physical, chemical and biological characteristics of wastewater-determination of solids and organic matter-dissolved oxygen (Oxygen Sag Curve) - biochemical oxygen demand-chemical oxygen demand - wastewater microbiology.

Module 2: Wastewater Treatment Methods (10 Hours)

Wastewater treatment methods - pretreatment - primary treatment - secondary treatment - tertiary treatment-advanced treatment methods. Screening, grit removal, oil removal and equalization-neutralization, coagulation, flocculation and sedimentation - clarifiers and clariflocculation. Aerobic and anaerobic biological processes - activated sludge process - trickling filters - oxidation ditch - aeration lagoon - rotating biological contactors - aerobic fluidized bed bioreactors. Anaerobic digestion process - anaerobic filter - anaerobic contact process - anaerobic fluidized bed bioreactors - up flow anaerobic sludge blanket (UASB) – Disinfections: Chlorination and Ozonation – Adsorption sand filters.

Module 3: Sludge treatment, Solid and Hazardous Waste Treatment (10 Hours)

Sludge treatment and disposal - sludge thickening - sludge conditioning - sludge dewatering - sludge digestion and composting.

Solid waste treatment-sources and classification-collection and disposal methods-open dumping-sanitary landfill-incineration-composting.

Treatment of industrial waste - pulp and paper mill - textile mill - distillery - dairy - petroleum refinery - fertilizer industry.

Hazardous waste -types of hazardous waste - health effects – treatment and disposal methods.

Module 4: Air Quality: Definition, Characteristics and Perspectives (8 Hours)

Air pollution: Units of measurement, sources, classification. Sampling and analysis of air pollutants, Effects of air pollution- global effects of air pollution - global warming and ozone depletion. Meteorological phenomena on air quality-lapse rates, Pressure, Wind, Moisture and dispersion. Air quality modelling: Pasquill's stability class, Gauss dispersion model, design of Stack height.

Module 5: Engineered Systems for Air and Noise Pollution Control (8 Hours)

Air pollution control methods and equipment. Control Devises for Particulate Contaminants: Gravitational settling, Centrifugal Collectors, Wet Collectors, Fabric filters and Electrostatic Precipitators (ESP) Control Devices for Gaseous Contaminants: Adsorption, Absorption, Condensation, Combustion, Automobile Emission Control. Noise pollution - effects of noise on people-Noise control methods.

Text Books

1. Metcalf & Eddy, Wastewater Engineering: Treatment, Disposal and Reuse, McGraw-Hill
2. Peavy, H.S., Rowe, D.R. and Tchobanoglous, G., Environmental Engineering, McGraw-Hill
3. Sawyer and McCarty, Chemistry for Environmental Engineering, McGraw-Hill
4. Rao C.S., Environmental Pollution Control Engineering, New age International Pub.
5. Rao M.N. & Rao H., Air Pollution, Tata McGraw-Hill.
6. Tchobanoglous, Theisen and Eliassen, Solid wastes: Engineering Principles and Management Issues, McGraw-Hill

Reference Books

1. Austin G.T. (Ed.), Shreve's Chemical Process Industries, McGraw-Hill
2. Babbitt H.E., Sewage & Sewage Treatment, John Willey
3. Chemtech I, Chem. Eng. Curriculum Dev. Centre, IIT-Madras
4. Gopal Rao M. & Sittig M. (Eds.), Dryden's Outlines of Chemical Technology, Affiliated East West Press.
5. Mahajan S.P., Pollution Control in Process Industries, Tata McGraw-Hill
6. Perkins H.C., Air Pollution, McGraw-Hill
7. Sincero A.P. & Sincero G.A., Environmental Engineering-A Design Approach, Prentice Hall of India

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Introduction to Environmental Engineering-Water and Wastewater Treatment (9 Hours)**	
1.1	Environmental legislation and regulation-water quality standards (WHO, IS 10500:1991 Standard)-Water treatment methods	1 Hour
1.2	Sources of wastewater, Types of water pollutants and effects	1 Hour
1.3	Wastewater sampling, preservation and analysis	1 Hour
1.4	Physico-chemical characteristics of wastewater	2 Hours
1.5	DO (Oxygen Sag), BOD and COD of wastewater	2 Hours
1.6	Biological Characteristics of wastewater	2 Hours
2	**Wastewater Treatment Methods (10 Hours)**	
2.1	Primary Treatment	2 Hours
2.2	Secondary Treatment: Aerobic Process	2 Hours
2.3	Secondary Treatment: Anaerobic Process	3 Hours
2.4	Tertiary treatment: Sand filter, Adsorption, Ion-exchange, Disinfection	3 Hours
3	**Sludge treatment, Solid and Hazardous Waste Treatment (10 Hours)**	

3.1	Sludge from various stages, Treatment and Disposal methods	2 Hours
3.2	Solid waste treatment: sources, classification - collection and disposal methods	3 Hours
3.3	Industrial Waste treatment methods: pulp and paper mill - textile mill - distillery - dairy - petroleum refinery - fertilizer industry	3 Hours
3.4	Hazardous waste disposal: Types, health effect, treatment & disposal	2 Hours
4	**Air Quality: Definition, Characteristics and Perspectives (8 Hours)**	
4.1	Air pollution: Units of measurement, sources, classification	2 Hours
4.2	Sampling and analysis, Effects of air pollution	2 Hours
4.3	Meteorological phenomena on air quality-lapse rates, Pressure, Wind, Moisture and dispersion	1 Hour
4.4	Air quality modelling: Pasquill's stability class, Gauss dispersion model, design of Stack height (Numerical Problem)	3 Hours
5	**Engineered Systems for Air and Noise Pollution Control (8 Hours)**	
5.1	Control Devises for Particulate Contaminants: Gravitational settling, Centrifugal Collectors, Wet Collectors, Fabric filters and Electrostatic Precipitators (ESP)	3 Hours
5.2	Control Devises for Gaseous Contaminants: Adsorption, Absorption, Condensation, Combustion	2 Hours
5.3	Automobile Emission Control	1 Hour
5.4	Noise pollution - effects of noise on people-Noise control methods	2 Hours

CHT305	CHEMICAL REACTION ENGINEERING	CATEGORY	L	T	P	CREDIT
		PCC	3	1	0	4

Preamble: Sound knowledge in Reaction Engineering is very important for Chemical Engineers. The goal of this course is to develop a critical approach to chemical reactor design. This course would enable students to gain knowledge with respect to kinetics of homogeneous reaction, provide a foundation on deriving rate expressions for series, parallel, reversible reactions by the interpretation of batch reactor data, design of ideal reactors, design for single and for multiple reactions, non isothermal reactor design and incorporation of non ideality in reactor design.

Prerequisite: Basic knowledge in Chemical Process Principles & Chemical Engineering Thermodynamics

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

CO 1	Explain the principles of chemical kinetics and determine chemical kinetic parameters using batch reactor data.
CO 2	Design of chemical reactors under ideal conditions.
CO 3	Design of single and multiple reactions in ideal reactors.
CO 4	Design chemical reactors for non-isothermal operations.
CO 5	Design chemical reactors for non-ideal conditions.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3										
CO 2	3	2	3									
CO 3	3	2	3									
CO 4	3	2	3									
CO 5	3	2	3									

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	10
Understand	20	20	20
Apply	20	20	70
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

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

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

Course Level Assessment Questions

Course Outcome 1 (CO1): Explain the principles of chemical kinetics and determine chemical kinetic parameters using batch reactor data.

1. Device a mechanism for HBr reaction $H_2 + Br_2 \rightarrow 2HBr$

$$r_{HBr} = \frac{k[H_2][Br_2]^{\frac{1}{2}}}{1+k'\frac{[HBr]}{[Br_2]}}$$

2. The following data are obtained at $0^{O}C$ in a constant volume batch reactor using pure gaseous A for the reaction A → 2.5R.

Time(min)	0	2	4	6	8	10	12	14	∞
pA, mm Hg	760	600	475	390	320	275	240	215	150

Find the rate equation which satisfactorily represents the data.

3. Find the overall order of the reaction from the following constant volume data using equimolar amount of hydrogen and nitric oxide.

$$2H_2 + 2NO \rightarrow N_2 + 2H_2O$$

Total pressure, mm of Hg	200	240	280	320	360
Half-life, sec	265	186	115	104	67

Course Outcome 2 (CO2): Design of chemical reactors under ideal conditions.

1. Establish the performance equation of a piston flow reactor, where the reaction is A → R which is a first order irreversible gas phase reaction.
2. An aqueous reaction A+ B→ products with known kinetics $-r_A$= 500 litre/ mol.min C_AC_B is to takes place in an experimental tubular reactor under the following condition. Volume of reactor V= 0.1 litre. Volumetric flow rate v = 0.05 litre/min. Concentration of the reactant feed $C_{A0}=C_{B0}$ = 0.01 mol/ litre.

a. What fractional conversion of reactants can be expected?
b. For the same conversion in part A what size of stirred tank reactors is needed.
c. What conversion can be expected in a MFR equal in size to a PFR.

3. An aqueous reactant stream (4 mol A/liter) passes through a mixed flow reactor followed by a plug flow reactor. Find the concentration at the exit of the plug flow reactor if in the mixed flow reactor C_A= 1 mol/liter. The reaction is second-order with respect to A, and the volume of the plug flow unit is three times that of the mixed flow unit.

Course Outcome 3 (CO3): Design of single and multiple reactions in ideal reactors.

1. Show that performance of a N equal size mixed flow reactor in series approaches to a performance equation of PFR. Assume reaction is first order
2. Obtain maximum concentration of R for a reaction A→R→S which occurs in mixed flow reactor.
3. Derive the performance equation of recycle reactor.

Course Outcome 4 (CO4): Design chemical reactors for non-isothermal operations.

1. An irreversible first order isomerisation reaction A→ R is carried out in liquid phase in a MFR. Rate constant k at 1650C is 0.7 hr^{-1}. Activation energy is 120000 J/mol. Heat of reaction is -350KJ/kg. Heat capacity of reactants and products are 1.95 KJ/kg K. Volumetric flow rate is 0.33 m^3 /hr. Feed temperature is 20^oC and conversion expected is 95%. Calculate the reactor size and temperature of the reaction mixture if the reactor is operated adiabatically.
2. The first order liquid phase reaction A→ R is carried out in a MFR. The concentration of reactant in the feed is 4 mol/l. Volumetric flow rate is 200 cm^3 /s. Density and specific heat of the reaction mixture are 1.2 g/cm^3 and 0.9 cal/g ^0C. The volume of the reactor is 10 lit. The reactor operates adiabatically. The feed enters at temperature 200^0C. Determine the possible temperatures and conversions for stable, adiabatic operation.
3. Derive the expression for conversion for a non isothermal adiabatic reaction starting from the energy balance equation.

Course Outcome 5 (CO5): Design chemical reactors for non-ideal conditions.

1. Discuss the importance of residence time distribution studies the design of chemical reactors. Also obtain the relation between C, E and F curves.
2. In a reactor liquid decomposing with rate $-r_A= kC_A$ where k=0.307 min^{-1}. Find the fraction of reactants unconverted in the real reactor of the same size. RTD study conducted in the reactor gives following data.

Time	0	5	10	15	20	25	30	35
Tracer output, conc. gm/litre of fluid	0	3	5	5	4	2	1	0

3. Discuss briefly on determination of E and F curve in a laminar flow reactor.

Model Question paper

QP CODE: **PAGES:3**

Reg No:______________ **Name :______________**

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
FIFTH SEMESTER B. TECH DEGREE EXAMINATION, MONTH & YEAR
Course Code: CHT305
CHEMICAL REACTION ENGINEERING

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

(2019-Scheme)

PART A

(Answer all questions, each question carries 3 marks)

1. Define molecularity and order of a chemical reaction.
2. The rate constants of a certain reaction are 1.6×10^{-3} and 1.625×10^{-2} $(s)^{-1}$ at 10°C and 30°C. Calculate the activation energy in KJ/mol.
3. Define space time and space velocity.
4. Explain on different types of ideal reactors.
5. Define an autocatalytic reaction. Give an example.
6. Explain on recycle ratio and recycle reactor.
7. List the steps involved in non-isothermal reactor design.
8. Write note on optimum temperature progression.
9. Explain the importance of RTD studies in non-ideal reactors.
10. List the properties of tracers in RTD studies.

PART B

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

Module I

11. a. Device a mechanism for HBr reaction $H_2 + Br_2 \rightarrow 2HBr$

$$r_{HBr} = \frac{k[H_2][Br_2]^{\frac{1}{2}}}{1+k'\frac{[HBr]}{[Br_2]}}$$

(7)

b. Derive the integral equation for a second order reaction with equimolar concentrations of the reactants. (7)

12. a. The half-life period for a certain first order reaction is 2.5×10^{3}s. Determine the time taken for ¼ of the reactant to be left behind. (7)

b. After 8 minutes in a batch reactor, reactant (C_{A0} = 1 mol/liter) is 80% converted; after 18 minutes, conversion is 90%. Find a rate equation to represent this reaction. (7)

Module II

13. a. Establish the performance equation of a piston flow reactor, where the reaction is $A \rightarrow R$ which is a first order irreversible gas phase reaction. (6)

b. An aqueous reactant stream (4 mol A/liter) passes through a mixed flow reactor followed by a plug flow reactor. Find the concentration at the exit of the plug flow reactor if in the mixed flow reactor C_A = 1mol/liter. The reaction is second-order with respect to A, and the volume of the plug flow unit is three times that of the mixed flow unit. (8)

14. a. Derive the performance equation for a batch reactor. (6)

b. The reaction of triphenyl methyl chloride (trityl) (A) and methanol (B),

$$A+B \rightarrow C+D$$

was carried out in a batch reactor and the following data were obtained.

Time, min	0	50	100	150	200	250	300
Concentration of A $(mol/dm^3) \times 10^3$	50	38	30.6	25.6	22.2	19.5	17.4

The initial concentration of methanol was 0.5 mol/dm^3. Determine the reaction order with respect to triphenyl methyl chloride and the specific reaction rate constant. (8)

Module III

15. a. Show that performance of a N equal size mixed flow reactor in series approaches to a performance equation of PFR. Assume reaction is first order. (7)

b. Explain the method to determine the minimum size of two mixed reactors connected in series to achieve a specified conversion. (7)

16. a. Show that performance of a N equal size mixed flow reactor in series approaches to a performance equation of PFR. Assume reaction is first order. (7)

b. For a liquid feed (n=1, C_{A0} = 10 mol/liter) to a plug flow reactor with recycle of product (R = 2), 90% conversion is obtained. If the recycle stream is shut off, determine by how much this will lower the processing rate of feed to the same 90% conversion. (7)

Module IV

17. The first order liquid phase reaction $A \rightarrow R$ is carried out in a MFR. The concentration of reactant in the feed is 4 mol/l. Volumetric flow rate is 200 cm3 /s. Density and specific heat of the reaction mixture are 1.2 g/cm3 and 0.9 cal/g 0C. The volume of the reactor is 10 lit. The reactor operates adiabatically. The feed enters at temperature 200C. Determine the possible temperatures and conversions for stable, adiabatic operation.

Take ΔHr= -46000 cal/mol and k= $1.8 \times 10^5 \exp(-12000/RT), s^{-1}$. (14)

18. a. Derive the expression for conversion for a non isothermal adiabatic reaction starting from the energy balance equation. (7)

b. Develop the expression to find the variations of equilibrium constants with temperature. **(7)**

Module V

19. a. Discuss the importance of residence time distribution studies the design of chemical reactors. Also obtain the relation between C, E and F curves. (10)

b. Explain causes for non ideality in real reactors (4)

20. a. In a reactor liquid decomposing with rate $-r_A = kC_A$ where k=0.307 min^{-1}. Find the fraction of reactants unconverted in the real reactor of the same size. RTD study conducted in the reactor gives following data

Time	0	5	10	15	20	25	30	35
Tracer output, conc. gm/litre of fluid	0	3	5	5	4	2	1	0

(8)

b. Discuss briefly on determination of E and F curve in a laminar flow reactor. (6)

Syllabus

Module 1(10 hours)

Overview of chemical reaction engineering. Classification of chemical reactions. Variables affecting the rate of reaction. Definition of reaction rate. Kinetics of homogeneous reaction. Concentration dependent term of rate equation. Kinetic models for Nonelementary reactions. Temperature dependent term of rate equation. Temperature dependency from Arrhenius law, Collision theory and transition state theory (no derivation).

Interpretation of batch reactor data-Evaluation of rate equation by integral and differential analysis for constant volume and variable volume system

Module 2 (8 hours)

Introduction to reactor design. Classification of reactors. Ideal reactors for a single reaction-Ideal batch reactor- Steady state mixed flow reactor-Steady state plug flow reactor. Holding time and space time for flow reactors.

Module 3 (12 hours)

Design for single reactions-Size comparison of single reactors- Multiple reactor systems-Plug flow reactor in series and parallel, equal sized mixed reactors in series, mixed flow reactors of different sizes in series, determination of the best system for a given conversion. Recycle reactor. Auto catalytic reactions. Design for multiple reactions, Reactions in parallel, contacting patterns for reactions in parallel.

Module 4 (7 hours)

Non isothermal reactor design - Temperature and pressure effects - single reactions-Heat of reaction from thermodynamic, heat of reaction and temperature, equilibrium constants from thermodynamics. General graphical design procedure, optimum temperature progression. Heat effects: adiabatic operations and non-adiabatic operations Multiple Steady States in CSTR. Multiple reactions: Product distribution and temperature.

Module 5 (8 hours)
Non ideality in reactors- Basics of non ideal flow- Residence time distribution studies-C, E & F curves and their relationships. Conversion in non ideal reactors.
RTD in ideal reactors: Batch and plug flow reactors, single CSTR, Laminar flow reactor. Models for non ideal flow-dispersion model and tank in series model.

Text Books
1. Levenspiel Octave, "Chemical Reaction Engineering", John Wiley & Sons, Third Edition.
2. H Scott Fogler, "Elements of Chemical Reaction Engineering", Prentice Hall of India, Fifth Edition.
3. Smith J.M, "Chemical Engineering Kinetics," McGraw Hill.

Reference Books
1. James J Carberry, "Chemical &Catalytic Reaction Engineering", Mc Graw Hill.
2. K.G Denbigh& J.C.R Turner, "Chemical Reactor Theory- An Introduction", Cambridge University Press.
3. Lanny D Schmidt, "The Engineering of Chemical Reactions", Oxford University Press.
4. Ronald W. Missen, Charles A. Mims, Bradley A. Saville, „Introduction to Chemical Reaction Engineering and Kinetics‟, John Wiley & Sons
5. Hill C.G., An Introduction to Chemical Engineering Kinetics & Reactor Design, John Wiley

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Module I (10 Hours)**	
1.1	Overview of chemical reaction engineering. Classification of chemical reactions. Variables affecting the rate of reaction.	1
1.2	Definition of reaction rate. Kinetics of homogeneous reaction. Concentration dependent term of rate equation.	1
1.3	Kinetic models for Non-elementary reactions.	2
1.4	Temperature dependent term of rate equation. Temperature dependency from Arrhenius law, Collision theory and transition state theory (no derivation).	1
1.5	Interpretation of batch reactor data. Evaluation of rate equation by integral analysis for constant volume system	3
1.6	Evaluation of rate equation by differential analysis for constant volume system	1

1.7	Evaluation of rate equation by integral analysis for variable volume system	1
2	**Module II (8Hours)**	
2.1	Introduction to reactor design. Classification of reactors.	1
2.2	Ideal reactors for a single reaction- Ideal batch reactor	2
2.3	Steady state mixed flow reactor	2
2.4	Steady state plug flow reactor.	2
2.5	Steady state plug flow reactor.	1
3	**Module III (12 Hours)**	
3.1	Design for single reactions-Size comparison of single reactors	2
3.2	Multiple reactor systems- Plug flow reactor in series and parallel	1
3.3	Equal sized mixed reactors in series, mixed flow reactors of different sizes in series, determination of the best system for a given conversion.	3
3.4	Recycle reactor and Auto catalytic reactions.	3
3.5	Design for multiple reactions: Reactions in parallel, contacting patterns for reactions in parallel.	3
4	**Module IV (7 Hours)**	
4.1	Non isothermal reactor design - Temperature and pressure effects - single reactions- Heat of reaction from thermodynamic	1
4.2	Heat of reaction and temperature, equilibrium constants from thermodynamics.	1
4.3	General graphical design procedure, optimum temperature progression.	1
4.4	Heat effects: adiabatic operations	1
4.5	Heat effects: non-adiabatic operations	1
4.6	Multiple Steady States in CSTR.	1
4.7	Multiple reactions: Product distribution and temperature.	1
5	**Module V (8 Hours)**	
5.1	Non ideality in reactors. Basics of non ideal flow.	1
5.2	Residence time distribution studies-C, E & F curves and their relationships.	2
5.3	Conversion in non ideal reactors.	1
5.4	RTD in ideal reactors: Batch and plug flow reactors, single CSTR, Laminar flow reactor.	2
5.5	Models for non ideal flow-dispersion model and tank in series model.	2

CHT307	INSTRUMENTATION AND PROCESS CONTROL	CATEGORY	L	T	P	CREDIT
		PCC	3	1	0	4

Preamble: Sound knowledge in process control and instrumentation is very important for Chemical Engineers.Process control has become increasingly important in the process industries as a consequence of global competition, rapidly changing economic conditions, and more stringent environmental and safety regulations. Proper application of process control improves the safety and profitability of a process, while maintaining consistently the desired product quality.

This course would enable students to gain knowledge on application of Laplace transforms, frequency response etc. for obtaining transient response of first order systems, second order systems, controllers, feedback industrial control systems and their stable and safe range of operation.This course introduces students to some modern methods and tools used for measuring variables in a process industry which are essential for proper control and functioning of all equipments and processes

Prerequisite: Basic engineering mathematics and concepts of Laplace transforms

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

CO 1	Categorize measuring instruments for industrial applications and illustrate instrumentation for temperature, pressure, flow, level, composition and pH.
CO 2	Apply Laplace transforms to solve linear differential equations and to obtain the transfer function related to first order systems.
CO 3	Develop the response of linear open loop second order systems and systems in series for various forcing functions.
CO 4	Describe various types of controllers and analyse servo and regulatory problems of closed loop systems by using transient response.
CO 5	Analyze the stability of linear systems by using analytical and graphical methods. Design controllers.

Mapping of course outcomes with program outcomes

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

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	10
Understand	20	20	30
Apply	20	20	60
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

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

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

Course Level Assessment Questions

Course Outcome 1 (CO1):

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

Course Outcome 2 (CO2)

1. Solve the following equation using Laplace transforms:

$$25\frac{d2x}{dt2} + x = 1 \text{ with x (0) =0 and x'(0)=0.}$$

2. Find the final value of y(t) for the transfer function

$$y(s) = \frac{1}{s(s^3 + 3s^2 + 3s + 1)}$$

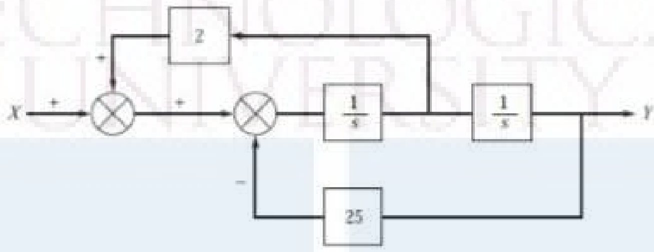
Course Outcome 3(CO3):

1. Explain each term with its significance in process control: overshoot, decay ratio, rise time, and settling time.

2. Assume thermometer in a thermo well as an under damped system; obtain the expression for response of thermometer when subjected to a step change in the surrounding temperature.

Course Outcome 4 (CO4):

1. Sketch the input and output functions for the following controller actions:
   a) Ramp input to a derivative controller
   b) Step input to a PI controller
2. Derive the transfer function Y/X for the control system shown in figure below.



Course Outcome 5 (CO5):

1. Describe Ziegler-Nichols tuning methodology.
2. State Bode stability criterion.
3. Determine the stability of the characteristic equation by Routh test.

$$2s^4 + s^3 + 3s^2 + 4s + 10 = 0$$

Model Question paper

QP CODE: **PAGES:3**

Reg No:_______________Name :_______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIFTH SEMESTER B. TECH DEGREE EXAMINATION,MONTH & YEAR

Course Code: CHT 307

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

(2019-Scheme)

PART A

(Answer all questions, each question carries 3 marks)

1. Suggest any 2 instruments each for low, medium and high pressure measurement
2. Describe the principle and working of radiation pyrometer
3. Sketch the following function
   f(t)=u(t)-2u(t-1)+u(t-3)
4. Determine the final value of the function

$$f(s) = \frac{(s+4)}{s(s-1)(s-2)(s+3)}$$

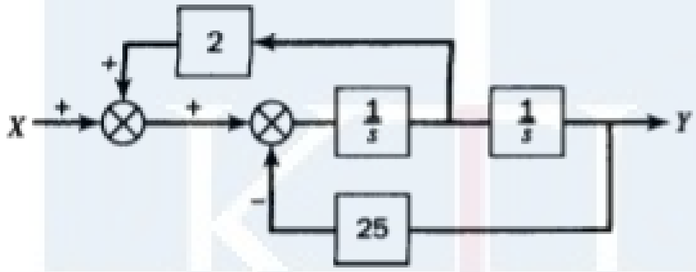
5. A step change of magnitude 1 unit is imparted to the input to a system of transfer function

$$\frac{Y(s)}{X(s)} = \frac{1}{s^2 + s + 1}$$

Determine overshoot, Decay ratio, Rise time and Period of oscillation if the time is measured in seconds.

6. Determine the transfer function $H_2(s)/Q(s)$ for the liquid level system show below: Resistances R_1 and R_2 are linear

7. Determine $\frac{C(s)}{R(s)}$.



8. Explain servo and regulator problem in control systems with suitable examples.
9. Explain Routh criterion of stability.
10. State Bode stability criterion.

PART B

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

Module I

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

b) explain static and dynamic characteristics of instruments. (6)

12. a) Illustrate the laws of thermoelectricity. Describe the k thermocouple and its application (8)

b). explain different class of instruments used for flow measurement (6)

Module II

13.a) State initial and final value theorem. (2 marks)

b) The function f(t) has the Laplace transform

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

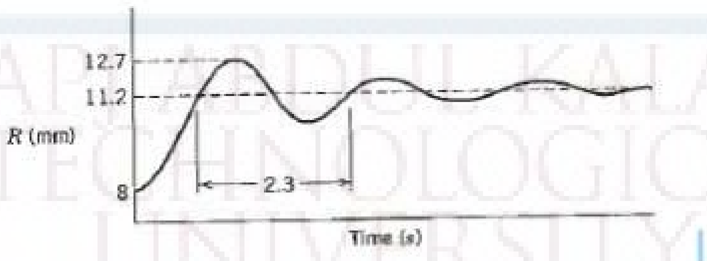
Obtain the function f(t) and graph f(t). (5 marks)

c) Solve the following by using Laplace transform.

$$\frac{d^2x}{dt^2} + \frac{dx}{dt} + x = 1, x(0) = x'(0) = 0$$ (7 marks)

Module III

14. a) A step change from 15 to 31 psi in actual pressure results in the measured response from a pressure-indicating element shown in figure below.

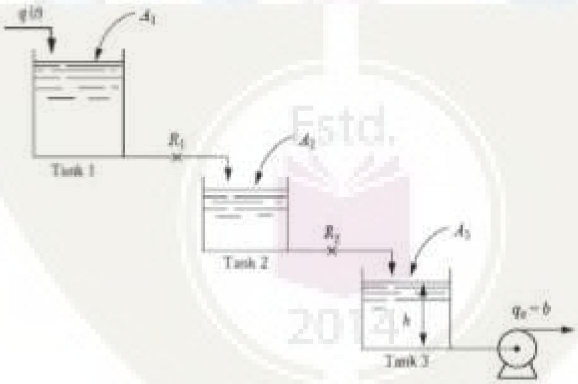


Assuming second order dynamics, determine (i) process gain, Kp, (ii) overshoot, (iii) decay ratio, (iv) damping coefficient, ζ and (v) time constant, τ. write the approximate second order transfer function. (9 marks)

b) Derive expression for H(s)/Q(s) for a non-interacting system. (5 marks)

15. a) A thermometer having a time constant of 1 min is initially at 50°C. It is immersed in a bath maintained at 100°C at t = 0. Determine the temperature reading at 1.2 min. (5 marks)

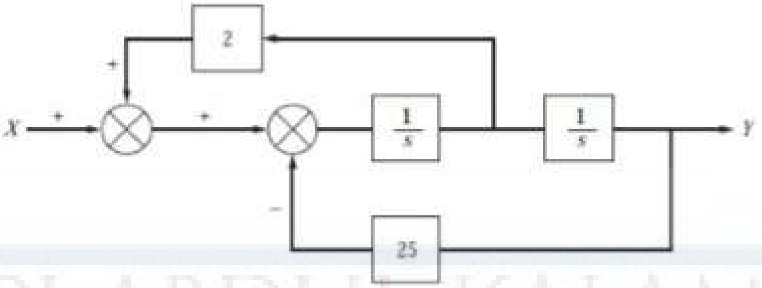
b)Determine the transfer function H (s)/Q (s) for the liquid-level system shown in fig. below Resistances R1 and R2 are linear. The flow rate from tank 3 is maintained constant at b by means of a pump; i.e., the flow rate from tank 3 is independent of head h. The tanks are non-interacting. (9 marks)



Module IV

16. a. List out the different types of controllers with its corresponding transfer function. (5 marks)

b. Derive the transfer function Y/X for the control system shown in figure below. (9 marks)



17. a. A feedback control system consists of a process and proportional controller. The transfer function of the process is

$$Gp(s) = \frac{3}{(10s+1)(5s+1)}$$

i. Calculate the value of the P-controller gain that will result in critically damped behaviour.
ii. If the controller gain obtained in (a) is used what will be the offset for a unit step change in set point.
iii. For a unit step change in set point, what will be controller gain to result an offset of 10%? (9 marks)

b. A unit step change in error is introduced into a PID controller. If K_c=10. Obtain the response of the controller. (5 marks)

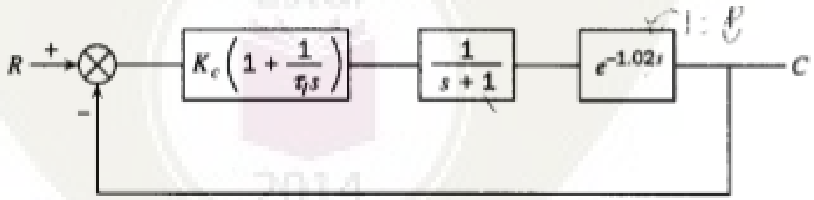
Module V

18. a. Obtain the Bode plot for the following open loop transfer function.

$$G(s) = \frac{100}{(10s+1)(s+1)}$$

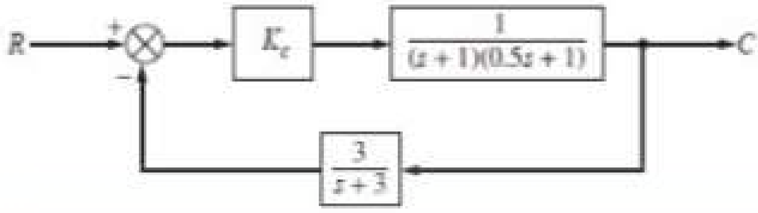
Determine the cross over frequency (10 marks)

b.Using the Ziegler-Nichols rules, determine K_c, and τ_I for the control system shown in Fig.



(4 marks)

19.a) Write the characteristic equation and construct the Routh array for the control system shown in figure.



Determine the stability of the system for (a) Kc = 9.5, (b) Kc = 11, and (c) Kc = 12.

(9 marks)

b. Explain the procedure to compute phase and gain margins from Bode plot. (5 marks)

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Syllabus

Module 1 (8 Hours)

Performance characteristics of measuring instruments: static and dynamic characteristics of measuring instrument. List of instruments for temperature, pressure, flow and level measurement. Detailed study of mercury in glass thermometer, thermocouples, thermistors, resistance thermometer, radiation pyrometer, bourden gauge, ionization meter, piezoelectric manometer, orifice meter, coriolis meter, differential pressure level measurement and high-pressure measurement. Conductivity meters, solid level detectors.

Module 2 (8 Hours)

Laplace transform - transform of simple functions – derivatives and integral - properties of Laplace transforms - final value theorem - initial value theorem - transition of transforms and functions – examples - inversion by partial fraction - solution of differential equations, Linear open loop systems - mercury thermometer, liquid level process: single tank.

Module 3 (8 Hours)

Interacting and non-interacting types, manometer - response of these towards different types of forcing functions: step and sinusoidal functions. Control valves- types, working principle, selection. P, PI and PID Controllers - basic principles and transfer functions

Module 4 (11Hours)

Closed loop system – feedback control- servo and regulator problems -block diagram development –Block diagram reduction-Transient response of simple control systems - step response and offset.

Introduction to stability of linear systems - Routh- Hurwitz criterion for stability -Root locus technique-plotting root locus diagram.

Module 5 (10 Hours)

Introduction to frequency response - substitution rule –. Bode diagram for first order systems - first order systems in series - second order systems - bode stability criterion, gain margin and phase margin.

Controller tuning- Ziegler-Nichol’s method - comparison of closed loop responses for different controller settings.

Text Books

1. Jain R K, Mechanical and Industrial measurements, Khanna publishers
2. Patranabis D, Principles of Industrial Instrumentation, Tata- McGraw Hill.
3. Coughanewr D.P., Process Systems Analysis& Control, McGraw Hill
4. Stephanopoulose G., Chemical Process Control, An Introduction to Theory & Practice, Prentice Hall of India
5. Dale E. Seborg, Thomas F. Edgar and Duncan A. Mellichamp, Process Dynamics and Control, John Wiley & Sons Inc. Second Edition.

Reference Books

1. Ernest O Doeblin, Measurement systems, Application and Design, McGraw Hill
2. Donald P Eckman, Industrial Instrumentation, CBS Publishers and Distributors, New Delhi
3. Eckman D.P., Principles of Industrial Process Control, John Wiley & Sons Inc, NY (1946)
4. Harriot P., Process Control, Tata McGraw Hill
5. Ceaglske N.H., Automatic Process Control for Chemical Engineers, John Wiley & Sons, NY, 1956

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Module I (8 hours)**	
1.1	Performance characteristics of measuring instruments: static and dynamic characteristics of measuring instrument.	1
1.2	List of instruments for temperature, pressure, flow and level measurement -range and principle	1
1.3	List of instruments for temperature, pressure, flow and level measurement-their selection wrt. requirements	1
1.4	Detailed study of mercury in glass thermometer, thermocouples, thermistors.	1
1.5	Resistance thermometer, radiation pyrometer,	1
1.6	bourden gauge, ionization meter, piezoelectric manometer,	1
1.7	orifice meter, coriolis meter, differential pressure level measurement	1
1.8	High pressure measurement. Conductivity meters, solid level detectors.	1
2	**Module II (8 hours)**	
2.1	Laplace transform - transform of simple functions	1
2.2	derivatives and integral	1
2.3	properties of Laplace transforms - final value theorem - initial value theorem	1
2.4	transition of transforms and functions – examples	1
2.5	inversion by partial fraction	1
2.6	solution of differential equations	1
2.7	Linear open loop systems - mercury thermometer	1
2.8	liquid level process: single tank.	1
3	**Module III (8 hours)**	
3.1	Interacting and non-interacting types	2
3.2	manometer	1
3.3	response of these towards different types of forcing functions: step and sinusoidal functions	2
3.4	Control valves- types, working principle, selection	1
3.5	P, PI and PID Controllers - basic principles and transfer functions	2
4	**Module IV (11 hours)**	

4.1	Closed loop system – feedback control- servo and regulator problems	3
4.2	block diagram development –	1
4.3	Block diagram reduction	1
4.4	Transient response of simple control systems - step response and offset.	2
4.5	Introduction to stability of linear systems - Routh- Hurwitz criterion for stability	2
4.6	Root locus technique-plotting root locus diagram	2
5	**Module V (10 hours)**	
5.1	Introduction to frequency response - substitution rule.	2
5.2	Bode diagram for first order systems	2
5.3	first order systems in series	1
5.4	second order systems - bode stability criterion, gain margin and phase margin	2
5.5	Controller tuning- Ziegler-Nichol's method	1
5.6	comparison of closed loop responses for different controller settings.	2

CHL331	HEAT TRANSFER OPERATIONS LAB	CATEGORY	L	T	P	CREDIT
		PCC	0	0	3	2

Preamble:
This course helps the students to understand the principles of various modes of heat transfer through experimental procedures.This practical course familiarizes the students the operations and working of various heat transfer equipment.

Prerequisite:
Theoretical knowledge of Process Heat Transfer.

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

CO 1	Experiment with various modes of heat transfer.
CO 2	Evaluation the heat transfer coefficients.
CO 3	Determine the rate of heat transfer in various modes of heat transfer.
CO 4	Analyse the working of heat transfer equipments.
CO 5	Interpret and present the experimental data meaningfully.
CO 6	Develop teamwork skills.

Mapping of course outcomes with program outcomes

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

Assessment Pattern

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	75	75	2.5 hours

Continuous Internal Evaluation Pattern:

Attendance	:15 marks
Continuous Assessment	:30 marks
Internal Test (Immediately before the second series test)	:30 marks

End Semester Examination Pattern: The following guidelines should be followed regarding award of marks

(a) Preliminary work	:15Marks
(b) Implementing the work/Conducting the experiment	:10 Marks
(c) Performance, result and inference (usage of equipments and trouble shooting)	: 25 Marks
(d) Viva voce	: 20 marks
(e) Record	: 5 Marks

General instructions: Practical examination to be conducted immediately after the second series test covering entire syllabus given below. Evaluation is a serious process that is to be conducted under the equal responsibility of both the internal and external examiners. The number of candidates evaluated per day should not exceed 20. Students shall be allowed for the University examination only on submitting the duly certified record. The external examiner shall endorse the record.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Find the thermal conductivity of insulating material for lagged pipe apparatus.
2. Find the theoretical and experimental heat transfer coefficient for natural convection.
3. Find the radiation constant and emissivity of heated brass cylinder.

Course Outcome 2 (CO2)

1. Plot the heat transfer coefficient versus tube length for the given natural convection apparatus.
2. Determine the convective heat transfer coefficient of forced convection.
3. Find the overall heat transfer coefficient for the shell and tube heat exchanger.

Course Outcome 3(CO3):

1. Determine Stefan Boltzmann constant using the given apparatus.
2. Find the critical radius of insulation.
3. Determine the emissivity of iron sphere.

Course Outcome 4 (CO4):

1. Find LMTD, overall heat transfer coefficient and effectiveness of the counterflow heat exchanger.
2. Find LMTD, overall heat transfer coefficient and effectiveness of the shell and tube heat exchanger.

3. Compare the effectiveness of shell and tube heat exchanger using LMTD and NTU method.

Course Outcome 5 (CO5):
1. Compare experimental and theoretical heat transfer coefficient for natural convection.
2. Find experimental and theoretical heat transfer coefficient for forced convection.

Course Outcome 6 (CO6):
1. Compare the LMTD for parallel and counterflow heat exchanger by performing experiment.
2. Explain the various parts of a shell and tube heat exchanger.
3. Demonstrate the working of a single effect evaporator.

LIST OF EXPERIMENTS (Minimum of 10 experiments are mandatory)
1. Heat Transfer by Natural Convection
2. Heat Transfer by Forced Convection
3. Thermal conductivity of Metal Rod
4. Heat transfer through Composite Wall
5. Heat transfer in Double pipe heat exchanger
6. Heat Transfer in Shell and Tube Heat Exchanger
7. Emissivity Measurement Apparatus
8. Heat Transfer in Fins
9. Unsteady State Heat Transfer
10. Heat Transfer in Agitated Vessels
11. Combined Convection and Radiation Heat Transfer
12. Radiation Heat Transfer
13. Drop and Filmwise Condensation
14. Determination of Critical Radius of Insulation
15. Any other experiment related to different modes of heat transfer with and without change of phase.

Reference Books
1. Datta B.K., Heat Transfer: Principles and Applications, Prentice Hall India.
2. McCabe W.L., Smith J.C. &Harriot P., Unit Operations in Chemical Engineering, McGraw Hill.
3. Hollman J.P., Heat Transfer, McGraw Hill.
4. R C Sachdeva, Fundamentals of Engineering Heat and Mass Transfer, New age International Publishers.

CHL333	PROCESS CONTROL LAB	CATEGORY	L	T	P	CREDIT
		PCC	0	0	3	2

Preamble: This laboratory course is designed to learn real time dynamics and controlling of process parameters such as temperature, pressure, level and concentration in simple basic systems.

Prerequisite: Basic knowledge in Instruments, Process dynamics and Control

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

CO 1	Sketch and use the calibration graphs of temperature and pressure measuring instruments
CO 2	Test the dynamics of first order systems like temperature, level and mixing processes
CO 3	Test the dynamics of second order systems such as thermometer with thermowell, tanks in series and U-tube manometer
CO 4	Test the characteristics of pneumatic control valves
CO 5	Experiment on the control of temperature, flow and level processes
CO 6	Experiment on controller tuning

Mapping of course outcomes with program outcomes(High-3, Medium-2, Low -1)

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

Assessment Pattern

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	75	75	2.5 hours

Continuous Internal Evaluation Pattern:

Attendance	:	15 marks
Continuous Assessment	:	30 marks
Internal Test (Immediately before the second series test)	:	30 marks

End Semester Examination Pattern: The following guidelines should be followed regarding award of marks

(a) Preliminary work	: 15Marks
(b) Implementing the work/Conducting the experiment	: 10 Marks
(c) Performance, result and inference (usage of equipments and trouble shooting)	: 25 Marks
(d) Viva voce	: 20 marks
(e) Record	: 5 Marks

General instructions: Practical examination to be conducted immediately after the second series test covering entire syllabus given below. Evaluation is a serious process that is to be conducted under the equal responsibility of both the internal and external examiners. The number of candidates evaluated per day should not exceed 20. Students shall be allowed for the University examination only on submitting the duly certified record. The external examiner shall endorse the record.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Draw the calibration curve of the given thermocouple and find its accuracy using the curve
2. Draw the calibration curve of the given U-tube manometer
3. Draw the calibration curve of the given pressure transducer

Course Outcome 2 (CO2)

1. Sketch the step response curve of the given thermocouple and find its time constant
2. Sketch the step response curve of the given bare thermometer and find its time constant
3. Sketch the step response curve of a single tank liquid level system and find its time constant
4. Sketch the impulse response curve of a stirred tank liquid mixing system and find its time constant

Course Outcome 3(CO3):

1. Sketch the step response curve of a two-tank non-interacting liquid level system and compare it with the theoretical response
2. Sketch the step response curve of a two-tank interacting liquid level system and compare it with the theoretical response

3. Sketch the step response curve of the given thermometer with thermowell and find the apparent time constants

Course Outcome 4 (CO4):

1. 1. Plot the installed characteristics of equal percentage pneumatic control valve
2. 2. Plot the inherent characteristics of linear control valve
3. 3. Plot and compare the inherent characteristics of quick opening control valve and linear control valve

Course Outcome 5 (CO5):

1. Obtain the closed loop response of the proportional controller for level control
2. Obtain the closed loop response of the proportional integral (PI) controller for Temperature control
3. Obtain the closed loop response of the proportional integral derivative (PID) controller for Temperature control

Course Outcome 6 (CO6):

1. Obtain the gain of the proportional controller for level control
2. Obtain the gain and integral time of the proportional integral (PI) controller for Temperature control
3. Obtain the controller parameters ofthe proportional integral derivative (PID) controller for level control

LIST OF EXPERIMENTS

Minimum **eight experiments** are mandatory in this lab course and shall be based on the following concepts:

- Calibration of instruments
- Dynamic response of typical first and second-order systems.
- Dynamic response of systems in series.
- Response of closed loop systems with different control configurations.
- Tuning of Controllers

Sl No.	Name of Experiment	No. of Hours
01	Dynamic Response of Mercury in Glass Thermometer	3 Hrs
02	Dynamic Response of U-tube Manometer	3 Hrs
03	Dynamics of thermocouple	3 Hrs
04	Dynamics of liquid level system - single tank	3 Hrs

05	Dynamics of liquid level system - non-interacting tanks in series		3 Hrs
06	Dynamics of liquid level system - interacting tanks in series		3 Hrs
07	Dynamic Response of Thermometer in Thermowell		3 Hrs
08	Dynamics of mixing process		3 Hrs
09	Pressure Control Trainer (Any four experiments of among the sub-list mandatory)	a) Study of open loop response (manual control) b) Study of on/off controller. c) Study of proportional controller d) Study of proportional integral controller e) Study of proportional derivative controller f) Study of proportional integral derivative controller g) Tuning of controller (open loop method) h) Tuning of controller (closed loop method) i) Tuning of controller (using auto tuning method) j) Study stability of the system (Bode plot)	3 Hrs
10	Temperature Control Trainer (Any four experiments of among the sub-list mandatory)	a) Study of open loop response (manual control) b) Study of on/off controller. c) Study of proportional controller d) Study of proportional integral controller e) Study of proportional derivative controller f) Tuning of controller (open loop method) g) Tuning of controller (closed loop method) h) Tuning of controller (using auto tuning method) i) Study stability of the system (Bode plot)	3 Hrs
11	Level Control Trainer (Any four experiments of among the sub-list mandatory)	a) Study of open loop response (manual control) b) Study of on/off controller. c) Study of proportional controller d) Study of proportional integral controller e) Study of proportional derivative controller f) Study of proportional integral derivative controller g) Tuning of controller (open loop method) h) Tuning of controller (closed loop method) i) Tuning of controller (using auto tuning method) j) Study stability of the system (Bode plot)	3 Hrs

12	Flow Control Trainer (Any four experiments of among the sub-list mandatory)	a) Study of open loop response (manual control) b) Study of on/off controller. c) Study of proportional controller d) Study of proportional integral controller e) Study of proportional derivative controller f) Study of proportional integral derivative controller g) Tuning of controller (open loop method) h) Tuning of controller (closed loop method) i) Tuning of controller (using auto tuning method) j) Study stability of the system (Bode plot)	3 Hrs
13	Calibration of Thermocouples		3 Hrs
14	Control Valve characteristics		3 Hrs
15	I to P and P to I Converter characteristics		3 Hrs
16	Control system design using MATLAB-Simulink **OR**Scilab-Xcos		3 Hrs
17	Any other experiments related to process dynamics and control on the basis of the course CHT 307 Instrumentation and Process Control		3Hrs

Reference Books

1. Albert C.L. &Coggen D.A., *Fundamentals of Industrial Control*, ISA
2. Ceaglske N.H., *Automatic Process Control for Chemical Engineers,* John Wiley & Sons Inc
3. Coughanowr D.R., *Process System Analysis & Control*, McGraw Hill
4. Eckman D.P., *Principles of Industrial Process Control*, John Wiley& Sons Inc
5. Harriot P., *Process Control*, Tata McGraw Hill
6. Stephanopoulose G., *Chemical Process Control- An Introduction to Theory & Practice*, Prentice Hall of India
7. Tsai T.H., Lane J.W. & Lom C.S., *Modern Control Techniques for the Processing Industries*, Marcel Dekker

SEMESTER V

MINOR

CHT381	OCCUPATIONAL HEALTH & INDUSTRIAL HYGIENE	CATEGORY	L	T	P	CREDIT
		VAC	3	1	0	4

Preamble: The purpose of this course is to place in perspective the many factors involved in relating various industrial and occupational factors to health and the rationale upon which the practice of industrial hygiene is based, including the anticipation, recognition, evaluation, and control of workplace stresses, the biological responses to these stresses, the body defence mechanisms involved, and their interrelationships.

Prerequisite: Nil

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

CO 1	Identify the existence of occupational safety and health hazardsin work places and explain the importance of industrial hygiene.
CO 2	Analyse and apply industrial hygiene strategies with respect to chemical, biological, and physical hazards.
CO 3	Identify occupational health and industrial hygiene standards, testing systems and monitoring techniques.
CO 4	Explain health-affecting agents, factors and stressors and how they relate to typical industrial processes, unit operations, and tasks.
CO 5	Apply the relevant regulatory and national consensus standards and legal threshold limit values around hazardous exposure.

Mapping of course outcomes with program outcomes

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

Assessment Pattern

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

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

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

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

Course Level Assessment Questions

Course Outcome 1 (CO1): Identify the existence of occupational safety and health hazards in work places and explain the importance of industrial hygiene.

1. Explain the term occupational diseases. Group them under physical agent, chemical agent & biological agent.
2. Define Occupational Health. Enlist occupational diseases due to metals & dusts.
3. Define Occupational epidemiology and write the applications with examples.

Course Outcome 2 (CO2): Analyse and apply industrial hygiene strategies with respect to chemical, biological, and physical hazards.

1. Explain various occupational diseases caused by metals, dusts, fumes and chemical compound.
2. Compare various routes of entry of toxicants in to the human body.
3. Define the term ergonomics. Explain its Application.

Course Outcome 3(CO3): Identify occupational health and industrial hygiene standards, testing systems and monitoring techniques.

1. Define Pneumoconiosis as per International Labour Organization. Name the various types Pneumoconiosis.
2. Define permissible exposure limit, threshold limit value, lethal dose and lethal concentration.
3. Write a note on Occupational Health Standards.

Course Outcome 4 (CO4): Explain health-affecting agents, factors and stressors and how they relate to typical industrial processes, unit operations, and tasks.

1. Write a short note on "Safety Measures for Electrical Work".
2. Explain the significance of knowing MSDS in handling Chemicals. "Chemical Substance affects the bodies" - Elaborate with examples.
3. Briefly explain the effects on health due to cold and heat radiation and laser beams and also to explain their control measures.
4. Explain the health effects by exposing of ammonia, halogenated gases, hydro carbons gases and fumes like NO_X, SO_X, Cl_2, HCl and H_2S.

Course Outcome 5 (CO5): Apply the relevant regulatory and national consensus standards and legal threshold limit values around hazardous exposure.

1. Describe the significance of Threshold Limit Value (TLV).
2. Explain: (i) MSDS (ii) EHS (iii) LD50.
3. Explain: (i) The Workmen's Compensation Act, (ii) OHSAS18001, (iii) Mines Act.1952 and (iv) The Factories Act, 1948.

Model Question paper

QP CODE: **PAGES:**

Reg. No: ______________Name: __________________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIFTH SEMESTER B. TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: CHT 381

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

OCCUPATIONAL HEALTH & INDUSTRIAL HYGIENE

PART – A

Answer All the Questions (10 x 3 = 30)

1. Name any three organizations in the field of occupational health.
2. List down the advantages of checklists while carrying out an occupational health audit.
3. Identify any three types of voice measurement techniques.
4. Describe the physical effect of whole-body vibration.
5. A large chemical spillage is to be cleaned with a flammable solvent manually.Write the possible health effects upon exposure to the solvent.
6. Identify the routes through which toxicants enter the biological systems.
7. Describe how the body parts prevent dust from entering the body.

8. Explain the method to identify a dust problem in a workplace.
9. Write shot note on TLVs.
10. Give reasons why PPE should be considered only after other control measures.

PART – B

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

Module 1

11. Describe the purpose of different sections of an organization's health and safety policy. (14 marks)

OR

12. Explain the main components of a health and safety management system. (14 marks)

Module 2

13. a) Explain types of engineering controls that can be used to reduce noise in work place. (4 Marks)
    b) Explain different types of non-ionizing radiations also describe the health effects that may be caused by non-ionizing radiation (10 Marks)

OR

14. a) List common hazards from electricity. (6 Marks)
    b) Write and explain the possible effect of electricity on the body. (8 Marks)

Module 3

15. a) Employees can be exposed to chemical agents in workplace. List and explain different forms of chemical agents. (7 Marks)
    b) Describe the control measures that could be used to reduce the risk of infection from biological organism. (7 Marks)

OR

16. a) Explain the factors influencing the intensity of toxic action in human body. (6 Marks)
    b) Explain the different control strategies that could be implemented for toxic vapour and mist exposure. (8 Marks)

Module 4

17. Explain the safety precautions that should be implemented to avoid occupational asthma. (14 Marks)

OR

18. Define the term 'ergonomics'. Outline the factors that should be considered in anergonomic assessment of a digital control system workstation. (14 Marks)

Module 5

19. Explain different assessment techniques for air borne contaminants in a workplace. (14 Marks)

OR

20. You are assigned to prepare MSDS for a solvent. Write a note on the different information required to prepare this MSDS. Also find out the applications of MSDS. (14 Marks)

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Syllabus

Module 1(9 Hours)
Overview of Occupational Health: Introduction, History of Occupational Health, Occupational Health Policy in India, National and International Organizations in the field of occupational health, OHS: its principles & functions, Diagnosis of Occupational Diseases, Occupational health hazards and its preventive measures - occupational health audit and occupational Health Survey, Occupational epidemiology – purpose, approach and significance. Occupational Safety and Health Legislations – ILO Conventions, NIOSH, EPA, The Workmen's Compensation Act, OHSAS18001, Mines Act.1952, The Factories Act, 1948, Water (Prevention & control of pollution) Act, 1974 and Air (Prevention & control of pollution) Act, 1981.

Module 2(8 Hours)
Physical Health Hazards & its Management: Noise - compensation aspects, noise exposure regulation, properties of sound, occupational damage, risk factors, sound measuring instruments, noise control program, industrial audiometry, hearing conservation programs. Vibration - types, effects, instruments, surveying procedure, permissible exposure limit.Ionizing radiation - types, effects, monitoring instruments, control programs, OSHA standard. Non-ionizing radiations - effects, types, radar hazards, microwaves and radio-waves, lasers, TLV. Other physical health hazards in industry including heat, cold,electricity, light, barometric pressure and electro-magnetic field.

Module 3(10 Hours)
Chemical Health Hazards & its Management: Toxicokinetic – absorption, metabolism, retention, entoxification, detoxification, excretion of toxic chemicals (xenobiotics), acute verses chronic effects, relation between work place exposure and health effects. Metals in Industry - Arsenic & its compounds, Cadmium & its compounds, Chromium & its compounds, Cobalt & its compounds, Fluoride, Lead & its compounds, Manganese, Mercury, Phosphorus and Uranium. Gas, Vapor & Mist in Industry - Carbon Monoxide, Hydrogen Cyanide, Hydrogen Sulphide, Chlorine, Phosgene, Ammonia. Organic Chemicals – Benzene and Toluene. Pesticides & its toxicity.
Biological Hazards & its Management: Occupational Zoonotic Diseases.

Module 4(9 Hours)
Occupational Lung Diseases & its Diagnosis: Occupational Lung Diseases like Silicosis, Asbestosis, Coal Worker's Pneumoconiosis, Mixed Dust Fibrosis. Occupational Asthma (i.e.Byssinosis) & Extrinsic Allergic Alveolitis (like Bagassosis).Pulmonary Function Test.ILO Radiograph on Pneumoconiosis .Notifiable Occupational Diseases in India as per Factories Act, 1948. ILO list of Occupational Diseases.
Ergonomics & Work Physiology: Introduction to Ergonomics, application of ergonomics in industry, Stress and performance, anthropometry and work physiology, physical fitness test in industry, fatigue, VO_2Max, workload.

Module 5(9 Hours)

Industrial Hygiene: Introduction, principles and practices. Chemical Stresses/Agents at workplace. Assessment of airborne contaminants in the work environment – including various methods of air-sampling for area and personal monitoring. Concept of thresh-hold limit values/permissible limits of exposure and recommended exposure limits in industry. Concept of air-borne contaminants by substitution, isolation, enclosure, wet methods, industrial ventilation – dilution and local exhaust systems. Material Safety Data Sheets (MSDS). Biological monitoring and its applications. Selection, use, care and maintenance of Respiratory & Non-respiratory Personal Protective Equipment.

Text Books:

1. Barbara A. Plog, Patricia J. Quinlan, Fundamentals of Industrial Hygiene (5th edition), National Safety Council Chicago,5th Edition (2001).
2. John J. Talty, Industrial Hygiene Engineering-Recognition, Measurement, Evaluation and Control, Noyes Data Corporation, USA (1999).
3. Frank R. Spellman, Industrial Hygiene Simplified-A Guide to Anticipation, Recognition, Evaluation, and Control of Workplace Hazards-Government Institutes (2006).
4. Daniel A. Crowl, Joseph F. Louvar, Chemical Process Safety: Fundamentals with Applications, Prentice Hall (2011).
5. Sam Mannan, Lees' Loss Prevention in the Process Industries: Hazard Identification, Assessment and Control, Vol: 1-3-Butterworth-Heinemann (2004).

Reference Books

1. Patty, "Industrial Hygiene and Toxicology", Wiley Inter science, 1979.
2. Industrial Ventilation Manual, American Conference of Government Industrial Hygienists, 1993
3. Encyclopaedia of "Occupational Health and Safety", Vol.I and II, published by international Labour Office, Geneva, 1985.
4. Clayton & Clayton, Patty`s"Industrial Hygiene and Toxicology", Vol.I, II and III, Wiley Inter science, 1986
5. Encyclopaedia of Occupational Safety and Health" ILO Publication, 1980.
6. Terry Brimson,"The health and safety guide", Mc Graw Hill Book Company, Europe-England.
7. Peter, P.,"Occupational health hazards"- A practical Industrial Guide (Second Edition).
8. "Safety and good house-keeping", NPC, New Delhi, 1985.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Overview of Occupational Health (9 Hours)**	
1.1	Introduction, History of Occupational Health, Occupational Health Policy in India, National and International Organizations in the field of occupational health	2
1.2	OHS: its principles & functions, Diagnosis of Occupational Diseases	1

1.3	Occupational health hazards and its preventive measures - occupational health audit and occupational Health Survey	1
1.4	Occupational epidemiology – purpose, approach and significance.	1
1.5	Occupational Safety and Health Legislations – ILO Conventions, NIOSH, EPA, The Workmen's Compensation Act	2
1.6	Occupational Safety and Health Legislations – OHSAS-18001, Mines Act.1952, The Factories Act, 1948	1
1.7	Occupational Safety and Health Legislations – Water (Prevention & control of pollution) Act, 1974 and Air (Prevention & control of pollution) Act, 1981.	1
2	**Physical Health Hazards & its Management (8 Hours)**	
2.1	Noise - compensation aspects, noise exposure regulation, properties of sound, occupational damage.	1
2.2	Noise -risk factors, sound measuring instruments, noise control program, industrial audiometry, hearing conservation programs.	1
2.3	Vibration - types, effects, instruments, surveying procedure, permissible exposure limit.	1
2.4	Ionizing radiation - types, effects, monitoring instruments, control programs, OSHA standard.	1
2.5	Non-ionizing radiations - effects, types, radar hazards, microwaves and radio-waves, lasers, TLV.	1
2.6	Other physical health hazards in industry including heat, cold, electricity, light, barometric pressure and electro-magnetic field.	3
3.1	**Chemical Health Hazards & its Management (7 Hours)**	
3.1.1	Toxicokinetic – absorption, metabolism, retention, entoxification, detoxification	1
3.1.2	Excretion of toxic chemicals (xenobiotics), acute verses chronic effects, relation between work place exposure and health effects.	2
3.1.3	Metals in Industry - Arsenic & its compounds, Cadmium & its compounds, Chromium & its compounds, Cobalt & its compounds, Fluoride, Lead & its compounds, Manganese, Mercury, Phosphorus and Uranium.	2
3.1.4	Vapor & Mist in Industry - Carbon Monoxide, Hydrogen Cyanide, Hydrogen Sulphide, Chlorine, Phosgene, Ammonia.	1
3.1.5	Organic Chemicals – Benzene and Toluene.Pesticides & its toxicity.	1
3.2	**Biological Hazards & its Management (3 Hours)**	
3,2,1	Occupational Zoonotic Diseases	3
4.1	**Occupational Lung Diseases & its Diagnosis (5 Hours)**	
4.1.1	Occupational Lung Diseases like Silicosis, Asbestosis, Coal Worker's Pneumoconiosis, Mixed Dust Fibrosis.	2
4.1.2	Occupational Asthma (i.e. Byssinosis) & Extrinsic Allergic Alveolitis (like Bagassosis).	1
4.1.3	Pulmonary Function Test. ILO Radiograph on Pneumoconiosis.	1
4.1.4	Notifiable Occupational Diseases in India as per Factories Act, 1948. ILO list of Occupational Diseases.	1

4.2	**Ergonomics & Work Physiology (4 Hours)**	
4.2.1	Introduction to Ergonomics, application of ergonomics in industry	2
4.2.2	Stress and performance, anthropometry and work physiology	1
4.2.3	Physical fitness test in industry, fatigue, VO2Max, workload.	1
5	**Industrial Hygiene (9 Hours)**	
5.1	Introduction, principles and practices. Chemical Stresses/Agents at workplace.	1
5.2	Assessment of airborne contaminants in the work environment – including various methods of air-sampling for area and personal monitoring.	1
5.3	Concept of thresh-hold limit values/permissible limits of exposure and recommended exposure limits in industry.	1
5.4	Concept of air-borne contaminants by substitution, isolation, enclosure, wet methods.	1
5.5	Industrial ventilation – dilution and local exhaust systems.	1
5.6	Material Safety Data Sheets (MSDS). Biological monitoring and its applications.	2
5.7	Selection, use, care and maintenance of Respiratory & Non-respiratory Personal Protective Equipment.	2

CHT 383	PETROLEUM REFINERY ENGINEERING	CATEGORY	L	T	P	CREDIT
		VAC	3	1	0	4

Preamble: This course introduces students to the concepts of petroleum refinery operations that are relevant and used for applications in chemical engineering. This course summarizes various petroleum refinery operations like prelimary, primary and secondary. It also explains the classification and evaluation of crude oil. It also outlines the treatments of petroleum products their properties, applications and test methods.

Prerequisite: Nil

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

CO 1	Apply the basic principles of chemical engineering in the storage, selection and evaluation of crude oil to optimize the refinery operation.
CO 2	Apply the basic principles of distillation in the atmospheric and vacuum distillation unit and analyze the preliminary refinery operation.
CO 3	Analyze thermal and catalytic conversion process as a part of the secondary conversion process.
CO 4	Judge the selection of various techniques to improve the quality of gasoline to meet the Bharath stage norms and treatment techniques to other petroleum products.
CO 5	Explain various test methods to the petroleum products to meet the specification and understand the properties and uses of petroleum products.

Mapping of course outcomes with program outcomes

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

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	20
Understand	10	10	30
Apply	20	20	40
Analyse	10	10	10
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

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

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

Course Level Assessment Questions

Course Outcome 1 (CO1): To apply the basic principles of chemical engineering in the storage, selection and evaluation of crude oil to optimize the refinery operation.

1. Write the classification of Petroleum refinery.
2. Give the significance of evaluation of oil stock.
3. Why TBP analysis is widely used for crude oil assay.

Course Outcome 2 (CO2): To apply the basic principles of distillation in the atmospheric and vacuum distillation unit and analyze the preliminary refinery operation.

1. How vacuum is generated in the VDU.
2. Why pre treatment is necessary for crude oil.
3. Discuss about the topping operation in the refinery.

Course Outcome 3(CO3): To analyze thermal and catalytic conversion process as a part of the secondary conversion process.

1. What are the advantages of thermal conversion process?
2. What are the advantages of Zeolite type catalyst used in the FCCU?
3. Name any five-technology supplier for catalytic cracking.

Course Outcome 4 (CO4): To judge the selection of various techniques to improve the quality of gasoline to meet the Bharath stage norms and treatment techniques to other petroleum products.
1. CCR is widely used in refinery. Why?
2. Discuss the significance of reforming process in the refinery.
3. Analyse the importance of isomerisation process in the refinery.

Course Outcome 5 (CO5): To explain various test methods to the petroleum products to meet the specification and understand the properties and uses of petroleum products.
1. Define cetane number. How the cetane number of diesel is determined.
2. Define smoke point. Discuss the features of smoke point apparatus.
3. Define viscosity index. Explain how the viscosity index is calculated.

Model Question paper

QP CODE: **PAGES:3**

Reg No:_______________ **Name :_______________**

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIFTH SEMESTER B. TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: CHT383

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

CHT 383 PETROLEUM REFINERY ENGINEERING

(2019-Scheme)

PART A

(Answer all questions, each question carries 3 marks)

1. Differentiate between TBP and ASTM distillation.
2. What do you mean by the complexity of the refinery?
3. What is the role of prefractionator?
4. What is the significance of Vacuum distillation unit?
5. Differentiate between thermal cracking and catalytic cracking.
6. FCCU is considered as gasoline engine of the refinery. Why.
7. What is the type and composition of catalyst used in reforming reaction?
8. Analyse the importance of isomerisation process in the refinery.
9. What are the properties and specification of superior kerosene?
10. Define Octane number and Cetane number. (10x3 = 30 marks)

PART B

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

MODULE I

11. a) Discuss the composition of Crude oil.
    b) Write the classification of storage tanks used in the refinery. Explain any one of them in detail. (7+7 = 14 marks)
12. a) Discuss about the evaluation of crude oil.
    b) What is GRM and how it is calculated. (9+5 = 14 marks)

MODULE II

13. With neat diagram explain the working of Electric desalter. What are the parameters affecting the performance of Electric desalter? (14 marks)

14. a) Write the classification of Furnaces used in the refinery.
    b) With neat diagram explain the working of ADU. (5+9 = 14 marks)

MODULE III

15. a) With neat diagram explain the working of Delayed coker.
    b) What are the advantages of Catalytic conversion process? (9+5 = 14 marks)

16. a) With neat diagram explain the working of Hydrocracker.
    b) What are the process parameters for hydro cracking? Explain. (9+5 = 14 marks)

MODULE IV

17. a) With a neat diagram explain the working of sulphuric acid alkylation process.
    b) Discuss the significance of hydro treatment in the refinery. (10+4 = 14 mark)

18. a) With neat diagram explain the working of CCR process.
    b) Draw a block diagram of hydrogen generation in refinery. (9+5 = 14 marks)

MODULE V

19. a) With neat diagram explain the Merox treatment of LPG.
    b) With neat diagram explain the dewaxing by chilling and pressing.
    (7+7 = 14 marks)

20. a) What are the properties, test methods and uses of Lubricating oil? Explain.
    b) What are the properties, test methods and uses of Bitumen? Explain.
    (7+7 =14 marks)

****

Syllabus

Module 1 (8 hrs)

Storage and transportation of crude oil and products. Classification, Composition and Evaluation of oil stock. Status of Petroleum industry in India. Classification of petroleum refinery. Fundamentals of Refinery economics, Refinery complexity. Challenges of Indian refinery and its prospects.

Module 2 (9 hrs)

Preliminary petroleum processing-Impurities in crude oil, Dehydration and desalting of crude- Electric Desalter - Process description, factors affecting the electric desalter. Pipe still furnaces and its operations. Distillation of crude - Pre-fractionator, Atmospheric topping unit, Vacuum distillation unit.

Module 3 (10 hrs)

Thermal Conversion process. Thermal cracking, Visbreaking, Coking – Delayed coking. Types and uses of petroleum coke.

Catalytic conversion process- Catalytic Cracking - Types of Catalyst. Process description of Fluid Catalytic cracking unit. Process description and applications of Hydro cracking. Comparison of Thermal, Catalytic and Hydro cracking.

Module 4 (10 hrs)

Quality up gradation of gasoline- Catalytic Reforming - Catalyst-Process description. Catalyst, Process description and application of Alkylation - Sulphuric acid alkylation, Isomerisation with Platinum catalyst. Supporting process in Refinery - Hydrogen production, Acid gas removal and Sulphur recovery process- Modified Claus process.

Treatment of gasoline- Copper Chloride process and Merox sweetening. Production and treatment of L.P.G. Diesel Hydro desulphurisation (DHDS) and production of Ultra low sulphur Diesel (ULSD), Bharath stage norms of Diesel and Gasoline.

Module 5 (8 hrs)

Treatment of Kerosene - Edeleanu process. Production and treatment of Lube - Phenol extraction. Dewaxing methods- Chilling and pressing and MEK dewaxing.

Properties, test methods and uses of Refinery products such as L.P.G, Gasoline, Jet fuel, Kerosene, Diesel fuel, Lube oil and Bitumen.

Text books:

1. Bhaskara Rao B.K, Modern Petroleum Refinery Process, Oxford& IBM
2. Dr. Ram Prasad, Petroleum Refining Technology, Khanna Publishers
3.

References:

- Dr. Kochu Baby Manjooran S, Modern Petroleum Chemistry
- James H. Garry Glenn E. Handwerk Mark J. Kaiser, Petroleum Refinery Technology and Economics, CRC Press, Taylor and Francis group.

- I D Mall, Petrochemical Process technology, Macmillan
- Nelson W.L, Petroleum Refinery Engineering, McGraw Hill
- Gopala Rao M & Sitting M, Dryden's Outline of Chemical Technology, Affiliated East West Press

Course Contents and Lecture Schedule

No.	Topic	No. of Lectures
1	**Module I (8 hrs)**	
1.1	Storage and transportation of crude oil and products	2hrs
1.2	Classification, Composition and Evaluation of oil stock	3hrs
1.3	Status of Petroleum industry in India and Classification of petroleum refinery	1hr
1.4	Fundamentals of Refinery economics	1hr
1.5	Challenges of Indian refinery and its prospects.	1hr
2	**Module II (Preliminary and Primary refinery operations) (9 hrs)**	
2.1	Impurities in crude oil, Dehydration and desalting of crude	1hr
2.2	Electric Desalter- Types, Process, factors affecting electric desalter	1hr
2.3	Furnaces and its operations	2hrs
2.4	Distillation of crude - Pre-fractionator, Atmospheric topping unit.	3hrs
2.5	Vacuum distillation unit	2hr
3	**Module III (Cracking and Coking Operations) (10 hrs)**	
3.1	Thermal cracking and its application	1hr
3.2	Visbreaking	1hr
3.3	Coking – Delayed coking	1hr
3.4	Types, properties and uses of petroleum coke	1hr
3.5	Catalytic cracking-Types of Catalyst	1hr
3.6	Fluid catalytic Cracking unit	2 hrs
3.7	Process description and applications of Hydro cracking	2 hr
3.8	Comparison of Thermal, Catalytic and Hydro cracking	1 hr
4	**Module IV (10 hrs)**	
4.1	Catalytic reforming- Catalyst-Process description	1hr
4.2	Catalyst, Process variables, Process description and application of Alkylation, Isomerisation	3hrs
4.3	Supporting process in Refinery- Hydrogen production, Acid gas removal and Sulphur recovery process- Modified Claus process.	2hrs
4.4	Treatment of gasoline- Copper Chloride process and Merox sweetening.	2hrs
4.5	Production and treatment of LPG	1hr
4.6	Diesel Hydro desulphurisation (DHDS) and production of Ultra low sulphur Diesel (ULSD), Bharath stage norms of Diesel and Gasoline	1 hr
5	**Module V (8 hrs)**	

5.1	Treatment of Kerosene- Edeleanu process. Production and treatment of Lube- Phenol extraction	3hrs
5.2	Dewaxing methods- Chilling and pressing and MEK dewaxing.	1 hr
5.3	Properties, test methods and uses of Refinery products such as L.P.G, Gasoline, Jet fuel, Kerosene, Diesel fuel, Lubricating oil, and Bitumen.	4 hrs

CHT385	POLYMER TECHNOLOGY	CATEGORY	L	T	P	CREDIT
		VAC	3	1	0	4

Preamble: This course imparts basic knowledge on polymers, which includes classification, theory and processing of high polymers. This also incorporates the study on the properties and applications of different polymers, testing of mechanical and physical properties which will enable the students in selecting suitable polymers for engineering applications. This course will provide immense scope for research in the area of material development.

Prerequisite: Basic concepts of Material Science

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

CO 1	Classify types and mechanisms of polymerization
CO 2	Summarize the classes, properties and engineering uses/applications of different polymeric materials
CO 3	Describe the concepts behind different types of molecular weights and methods for their determination.
CO 4	Analyse the rheology and mechanical properties of polymers
CO 5	Explain the processing methods and moulding techniques
CO 6	Describe the elastomer processing methods and vulcanization of rubber.

Mapping of course outcomes with program outcomes

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

Assessment Pattern

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination**
	1	**2**	
Remember	10	10	10
Understand	20	20	20
Apply	20	20	70
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

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

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

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. List the types of polymerisation giving suitable examples.
2. Outline the method of emulsion polymerisation.
3. Illustrate the kinetics of vinyl polymerisation.

Course Outcome 2 (CO2)

1. Evaluate the properties of phenol formaldehyde and outline its applications.
2. Classify polymers based on their structure.
3. Discuss the factors affecting polymer properties.

Course Outcome 3(CO3):

1. State and explain weight average and number average molecular weights.
2. Describe the viscosity average molecular weight determination.
3. Illustrate the end group analysis.

Course Outcome 4 (CO4):

1. Demonstrate the viscoelastic properties of polymers with a suitable model.
2. Define apparent viscosity. How is it measured?
3. Describe a method to determine melt flow index.

Course Outcome 5 (CO5):

1. Classify the additives used in polymer processing giving examples in each category.
2. Illustrate the injection moulding technique with a diagram.
3. Demonstrate wet, dry and melt spinning methods with proper diagrams.

Course Outcome 6 (CO6):
1. Describe the process of vulcanisation of rubber.
2. Discuss the compounding methods for elastomers.
3. Outline the characteristic features of nanocomposites.

Model Question paper

QP CODE: **Reg No:______________**

PAGES:3 **Name :______________**

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIFTH SEMESTER B. TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: CHT 385

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

CHT 385 POLYMER TECHNOLOGY

(2019-Scheme)

PART A

(Answer all questions, each question carries 3 marks)

1. State and explain functionality with examples.

2. Distinguish between addition and condensation polymerisation

3. Give three terms of expressing compositions of a gas mixture.

4. Illustrate the types of copolymers with examples.

5. What is glass transition temperature? List the factors affecting T_g.

6. Discuss the oxidative degradation of polymers.

7. With a neat diagram, classify fluids based on rheology.

8. Discuss the role of plasticizers and heat stabilizers in polymer processing.

9. What is meant by vulcanization of rubber?

10. Define nanocomposites. Mention their advantages and disadvantages. **(10x3=30)**

PART B

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

Module –1

11. a) Discuss the classification of polymers based on source, structure and thermal response giving suitable examples.

    b) Distinguish between cationic and anionic polymerisations.

12. a) Outline the steps involved in free radical polymerisation with a suitable example.

    b) Derive the kinetics of condensation polymerisation.

Module –2

13. a) List the types of averaging of molecular weights of polymers and define them.
    b) Sketch the molecular weight distribution curve and explain its significance.
14. State and explain the principle of light scattering method. With proper diagrams describe the determination of molecular weight by this method.

Module –3

15. a) What are nylons? Describe the properties and applications of nylons.
    b) Give the structure of polycarbonates. Describe preparation of polycarbonate and mention the properties.
16. a) Define bioplastics. Discuss the preparation, properties and applications of poly lactic acid.
    b) Write a note on butyl rubber.

Module –4

17. a) Define melt flow index. Illustrate a method for its determination.
    b) Demonstrate stress relaxation and creep with a suitable model.
18. a) What is rubber like elasticity? Explain.
    b) Discuss the functions of ultraviolet absorbers and flame retardants.

Module –5

19. a) With a neat diagram, describe the injection moulding technique.
    b) Explain the terms mastication and. mixing in the processing of elastomers.

20. a) Discuss the various spinning methods for fibres with proper sketches.
    b) What is a nanocomposite? Discuss the types of nanocomposites and their applications.

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Syllabus

Module 1 (9 Hrs)

Introduction to polymers-monomer, functionality, classification of polymer based on source, structure, application, thermal behaviour, mode of polymerization. Kinetics of polymerisation – addition polymerization and condensation polymerisation – free radical polymerization – anionic and cationic polymerization. Copolymerisation-Different types of copolymers – Characteristic features. Methods of polymerization – bulk, solution, suspension and emulsion polymerization.

Module 2 (9 Hrs)

Molecular weight of polymers – weight average and number average molecular weight – sedimentation and viscosity average molecular weights. Experimental methods for molecular weight determination – end group analysis, light scattering method – viscometry (Ostwald viscometer) intrinsic viscosity. Molecular weight distribution curve. Factors affecting polymer properties – crystallinity – orientation treatment – solubility of polymers – glass transition temperature – types of polymer degradation – effect of reinforcement on the properties.

Module 3 (9 Hrs)

Manufacture, properties and applications of polymers- Thermoplastics – ABS – acrylics – cellulose acetate – fluoropolymers (PTFE) – nylons – polycarbonate – PVC – PE– PP – PS – polyurethanes. Thermosetting plastics – epoxy – phenol formaldehyde – urea formaldehyde – polyesters – silicones. Bioplastics – Poly lactic acid (PLA). Elastomers- Butyl rubber -Nitrile rubber.

Module 4 (9 Hrs)

Properties of polymers – rheology- viscous flow – apparent viscosity – rubber like elasticity – stress strain behaviour of elastomers – viscoelasticity – stress relaxation and creep – measurement of rheological properties – melt flow index (MFI) – capillary rheometers. Estimation of tensile strength of polymers. Addictives for polymer processing - effect of additives used – plasticizers – colourants – heat stabilizers - antioxidants – ultraviolet absorbers – antistatic agents – flame retardants – blowing agents – lubricants and fillers.

Module 5 (9 Hrs)

Plastic processing – injection moulding – compression moulding – calendaring – blow moulding – extrusion – thermoforming – wet, dry and melt spinning methods for fibres – vulcanization of rubber — general study of elastomer processing - brief description of compounding methods. Introduction to nano composites-types and applications.

Text Books:

1. Billmeyer F.W., Text book of polymer science, John Wiley.
2. Gowariker V.R. Polymer Science, New Age.

Reference Books:

1. Premamoy Ghosh., Polymer Science and Technology, Tata Mc Graw Hill.
2. Rodrigues F., Principles of polymer systems, Tata Mc Graw Hill
3. Shah V.H., Handbook of plastic testing technology, Wiley, 1998

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Introduction to Polymers, Classification and kinetics (9 Hrs.)**	
1.1	Monomer, functionality	1
1.2	Classification of polymer based on source, structure, application, thermal behaviour, mode of polymerization	1
1.3	Kinetics of polymerization- addition polymerization- free radical polymerization- anionic and cationic polymerization	2
1.4	Kinetics of step growth polymerisation	1
1.5	Different types of copolymers- Characteristic features, Copolymer equation.	2
1.6	Methods of polymerization – bulk, solution, suspension and emulsion polymerization	2
2	**Molecular weight of polymers (9 Hrs.)**	
2.1	Weight average and number average molecular weight	1
2.2	Sedimentation and viscosity average molecular weight	1
2.3	Experimental methods of molecular weight determination- end group analysis.	1
2.4	Light scattering method - viscometry	2
2.5	Molecular weight distribution curve	1
2.6	Factors affecting polymer properties	1
2.7	Types of polymer degradation	2
3	**Manufacture, properties and applications Bioplastics, Elastomers (9 Hrs.)**	
3.1	Thermoplastics-ABS – acrylics – cellulose acetate – fluoropolymers (PTFE) – nylons.	2
3.2	Polycarbonate – PVC – PE– PP – PS – polyurethanes.	2
3.3	Thermosetting plastics – epoxy – phenol formaldehyde – urea formaldehyde– polyesters – silicones.	2
3.4	Bioplastics- Poly lactic acid.	1
3.5	Elastomers-Natural rubber- Butyl rubber- Nitrile rubber.	2
4	**Rheology and Testing of polymers and additives used (9 Hrs.)**	

4.1	Properties of polymers – rheology- viscous flow -stress strain behaviour of elastomers – viscoelasticity – stress relaxation and creep	3
4.2	Measurement of rheological properties – melt flow index (MFI) – capillary rheometers.	2
4.3	Testing of tensile strength of polymers.	1
4.4	Effect of additives used; plasticizers; colourants	1
4.5	Heat stabilizers; antioxidants; ultraviolet absorbers	1
4.6	Antistatic agents; flame retardants; blowing agents, Lubricants and fillers.	1
5	**Processing of plastics and elastomers (9 Hrs.)**	
5.1	Injection moulding – compression moulding	2
5.2	Calendaring – blow moulding- Extrusion – thermoforming –	2
5.3	wet, dry and melt spinning methods for fibres	1
5.4	Vulcanization of rubber -General study of elastomer processing methods.	2
5.5	Introduction to nano composites	2

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SEMESTER V

HONOURS

CHT 393	ADVANCED HEAT TRANSFER	CATEGORY	L	T	P	CREDIT
		VAC	3	1	0	4

Preamble:
The advanced course in heat transfer is the next higher level of the theory course *CHT 204 Heat Transfer Operations*. The course covers topics such as one-dimensional steady state conduction, multidimensional conduction, unsteady state conduction, heat transfer through extended surfaces and also deals with convective and radiative heat transport analysis.

Prerequisite: Basic knowledge in heat transfer operations.

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

CO 1	Apply the concepts of conduction heat transfer to the design of heat-transfer equipment and solve related engineering problems.
CO 2	Explain the concept and applications of heat transfer through extended surfaces.
CO 3	Elaborate the phenomenon of unsteady state conduction of various types.
CO 4	Apply the concepts of convection heat transfer to solve complex heat transfer problems.
CO 5	Apply the concepts of radiation heat transfer to solve complex heat transfer problems.

Mapping of course outcomes with program outcomes

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

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	10
Understand	20	20	20
Apply	20	20	70
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

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

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

Course Level Assessment Questions

Course Outcome 1 (CO1): Apply the concepts of conduction heat transfer to the design of heat-transfer equipment and solve related engineering problems.

1. Write short note on thermal conductivity of materials.
2. Write down the general heat conduction equation.
3. Derive the general three-dimensional heat conduction equation in spherical co-ordinate system.

Course Outcome 2 (CO2): Explain the concept and applications of heat transfer through extended surfaces.

1. Differentiate between fin efficiency and effectiveness.
2. Sketch three different types of fins.
3. Derive the expression for temperature distribution and heat flux for a rectangular fin.

Course Outcome 3 (CO3): Elaborate the phenomenon of unsteady state conduction of various types.

1. Define a semi-infinite solid.
2. What are Heisler charts?
3. Derive the expression for temperature distribution of a solid undergoing transient conduction. Assume negligible internal resistance.

Course Outcome 4 (CO4): Apply the concepts of convection heat transfer to the design of heat-transfer equipment and solve related engineering problems.

1. List out the factors that influence the convective heat transfer coefficient.
2. Explain thermal boundary layer.
3. Derive x-momentum equation.

Course Outcome 5 (CO5): Apply the concepts of radiation heat transfer to design of heat-transfer equipment and solve related engineering problems.

1. Write short note on thermal radiation.
2. State and explain Planck's law.
3. A gray surface is maintained at a temperature of 827 ^{0}C. If the maximum spectral emissive power at that temperature is 1.37 x 10^{10} W/m^3, determine the emissivity of the body and the wavelength corresponding to the maximum spectral intensity of radiation.

Model Question Paper

QP CODE: **PAGES:2**

Reg No:______________ **Name :______________**

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIFTH SEMESTER B. TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: CHT 393

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

ADVANCED HEAT TRANSFER

(2019-Scheme)

PART A

(Answer all questions, each question carries 3 marks)

1. Write short note on thermal conductivity of materials.
2. Write down the general heat conduction equation.
3. Differentiate between fin efficiency and effectiveness
4. Sketch three different types of fins.
5. Define a semi-infinite solid.
6. What are Heisler charts?
7. List out the factors that influence the convective heat transfer coefficient.
8. Explain thermal boundary layer.
9. Write short note on thermal radiation.
10. State and explain Planck's law.

PART B

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

Module -I

11. Derive the general three- dimensional heat conduction equation in spherical co-ordinate system.
12. A thick-walled tube of stainless steel having a k = 21.63 W/mK with dimensions of 0.0254 ID and 0.0508 OD is covered with a 0.0254 m thick layer of insulation (k = 0.2423 W/mK). The inside wall temperature of the pipe is 811 K and the outside surface of insulation is at 310.8 K. For a 0.305 m length of pipe, calculate the heat loss and also the temperature at the interface between the metal and the insulation.

Module -II

13. Derive the expression for temperature distribution and heat flux for a rectangular fin.
14. One end of a very long aluminium rod is connected to a wall at 140 ^{0} C, while the other end protrudes into a room whose air temperature is 15 ^{0} C. The rod is 3 mm in diameter and the heat transfer coefficient between the rod and the environment is 300 W/m^{2}K. Estimate the total heat dissipated by the rod taking its thermal conductivity as 150 W/mK.

Module -III

15. Derive the expression for temperature distribution of a solid undergoing transient conduction. Assume negligible internal resistance.
16. Explain chart solutions for unsteady state heat transfer.

Module -IV

17. Derive x-momentum equation.
18. Describe the development of hydrodynamic and thermal boundary layers.

Module -V

19. State and explain laws of radiation.
20. A gray surface is maintained at a temperature of 827 ^{0} C. If the maximum spectral emissive power at that temperature is 1.37 x 10^{10} W/m^3, determine the emissivity of the body and the wavelength corresponding to the maximum spectral intensity of radiation

(14x 5 =70)

Syllabus

Module 1 (Conduction heat transfer)

Review of conduction convection and thermal radiation fundamentals. Thermal conductivity. Temperature and pressure dependence of thermal conductivity. Thermal conductivity of solids, liquids and gases. Combined mechanisms of heat transfer. The general differential equation for energy transfer. Steady state one-dimensional conduction with and without heat generation.

Module 2 (Heat transfer from extended surfaces)

Heat transfer from extended surfaces. Rectangular plate fin of uniform cross section: Long fins, Fin with insulated end, Fins with convection off the end. Pin fin (spine) of uniform cross section. Efficiency and effectiveness of fins. Error estimation in temperature measurement. Multi-dimensional heat conduction - Conduction in two dimensional systems: Analytical solution to a thin, infinitely long rectangular plate without any heat source.

Module 3 (Unsteady state conduction)

Unsteady state conduction. Lumped parameter analysis; Systems with negligible internal resistance. Response time of a temperature measuring instrument. Systems with negligible surface resistance. Heat flow in an infinitely thick plate (Semi-infinite body). Systems with finite surface and internal resistance. Chart solutions of transient heat conduction problems.

Module 4 (Convection heat transfer)

Convection heat transfer. The convective heat transfer coefficient. The basic equations: continuity equation, the momentum equation and the energy equation. Heat transfer in laminar and turbulent flows. The boundary layer theory. Hydrodynamic and thermal boundary layers. Exact analysis of the laminar boundary layer. Approximate analysis of the thermal boundary layer.

Module 5 (Radiation heat transfer)

Radiation heat transfer: Nature of radiation. Thermal radiation. The intensity of radiation. Laws of radiation. Emissivity and absorptivity of solid surfaces. Radiant heat transfer between black bodies. Radiant heat transfer between gray surfaces. Radiation from gases. The radiation heat transfer coefficient.

Text Books

1. Welty J.R et al., *Fundamentals of Momentum, Heat and Mass Transfer*, John Wiley & Sons
2. Hollman J.P., *Heat Transfer*, McGraw Hill
3. Dutta B.K., *Heat Transfer: Principles and Applications*, Prentice Hall India

Reference Books

1. Bird et al., *Transport Phenomena*, John Wiley & Sons.
2. Foust A.S et al., *Principles of Unit Operations*, John Wiley & Sons.
3. McCabe W.L., Smith J.C. &Harriott P., *Unit Operations in Chemical Engineering*, McGraw Hill
4. Coulson J.M. & Richardson J.F., *Chemical Engineering*, Vol. I and II, ELBS, Pergamon Press
5. Geankopolis C J, *Transport Processes andSseparation Process Principles*, Prentice Hall of India, 4th Edition, Eastern Economy Edition (2004)
6. Incropera F P and DeWitt D P, *Introduction to Heat Transfer*, 2nd Ed John Wiley New York (1996).
7. M.Necati. Ozizik, *Heat transfer - A Basic Approach*, McGraw-Hill College (1985)
8. Kern D.Q., *Process Heat Transfer*, McGraw Hill

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Conduction heat transfer (9 hours)**	
1.1	Review of conduction convection and thermal radiation fundamentals.	3
1.2	Thermal conductivity. Temperature and pressure dependence of thermal conductivity. Thermal conductivity of solids, liquids and gases.	1
1.3	Combined mechanisms of heat transfer.	1
1.4	The general differential equation for energy transfer.	1

1.5	Steady state one-dimensional conduction with and without heat generation.	3
2	**Heat transfer from extended surfaces (9 hours)**	
2.1	Heat transfer from extended surfaces. Rectangular plate fin of uniform cross section: Long fins, Fin with insulated end, Fins with convection off the end.	3
2.2	Pin fin (spine) of uniform cross section.	1
2.3	Efficiency and effectiveness of fins.	1
2.4	Error estimation in temperature measurement.	1
2.5	Multi-dimensional heat conduction: Two- and three-dimensional systems (introduction only). Numerical solutions.	3
3	**Unsteady state conduction (9 hours)**	
3.1	Unsteady state conduction. Lumped parameter analysis; Systems with negligible internal resistance.	2
3.2	Response time of a temperature measuring instrument.	1
3.3	Systems with negligible surface resistance.	2
3.4	Heat flow in an infinitely thick plate (Semi-infinite body). Systems with finite surface and internal resistance.	3
3.5	Chart solutions of transient heat conduction problems.	1
4	**Convection heat transfer (9 hours)**	
4.1	Convection heat transfer. The convective heat transfer coefficient.	1
4.2	The basic equations: Continuity equation, the momentum equation and the energy equation.	2
4.3	Heat transfer in laminar and turbulent flows.	1
4.4	The boundary layer theory. Hydrodynamic and thermal boundary layers.	2
4.5	Exact analysis of the laminar boundary layer. Approximate analysis of the thermal boundary layer.	3
5	**Radiation heat transfer (9 hours)**	
5.1	Radiation heat transfer: Nature of radiation. Thermal radiation. The intensity of radiation.	2
5.2	Laws of radiation. Emissivity and absorptivity of solid surfaces.	2
5.3	Radiant heat transfer between black bodies. Radiant heat transfer between gray surfaces.	3
5.4	Radiation from gases. The radiation heat transfer coefficient.	2

CHT 395	PHYSICO CHEMICAL METHODS IN ENVIRONMENTAL ENGINEERING	CATEGORY	L	T	P	CREDIT
		VAC	3	1	0	4

Preamble:
This course presents the physical and chemical principles for the treatment of dissolved and particulate contaminants in water and wastewater. These concepts will provide an understanding of the design of commonly used unit operations in water and wastewater treatment systems. Applications will be discussed as well. Topics covered include water characteristics, reactor dynamics, filtration, coagulation/flocculation, sedimentation, adsorption, gas stripping, disinfection, and chemical oxidation.

Prerequisite: CHT303 Environmental Engineering

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

CO 1	Select suitable equipment for the physicochemical treatment of water and wastewater
CO 2	Design physicochemical processes for water and wastewater treatment
CO 3	Estimate the quantity of water/ wastewater and fluctuations of flow from various sources
CO 4	Design screens, grit chamber, equalization and floatation tank
CO 5	Explain the principles of adsorption and disinfection in wastewater treatment
CO 6	Explain the principles of ion-exchange and membrane process in wastewater treatment

Mapping of course outcomes with program outcomes

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

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	10
Understand	20	20	20
Apply	20	20	70
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

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

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

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Explain different types of settling.
2. Explain the merits and demerits of coagulation process in sewage treatment.
3. Explain different types of sedimentation tanks.
4. Explain in detail about the mechanism of filtration and different type filtration media.
5. Design a Rapid Sand Filter unit for 4 million litres per day (MLD) of supply with all its principal components.

Course Outcome 2 (CO2):

1. Explain the role of equalization tanks in wastewater treatment. Distinguish between two flow arrangements with flow diagram.
2. A settling column analysis is run on a type-I suspension. The settling column is 2 m tall and the initial concentration of the well-mixed sample is 650 mg/L. Results of the analysis are below:

Time, min.	0	58	77	91	114	154	250
conc. remaining, mg/L	650	560	415	325	215	130	52

What is the theoretical efficiency of the settling basin that receives this suspension if the loading rate is 2.4×10^{-2} m/min? Which parameters need to be varied to increase removal efficiency?

Course Outcome 3 (CO3):

1. The collection system in a town was studied for its dry-weather and wet-weather flow characteristics. The study, which lasted for three months. Showed the average peak dry weather flow to be 205 L/s, the average minimum dry-weather flow to be 46 L/s, and the average flow to be 96 L/s. The combined infiltration -inflow was found to be 70 L/s. The sewage inflow records were also analysed for the average flow of the driest months of each year (average of the flow during the successive months of June, July and August of each year of record) yielding the following probability distribution.

Average dry-weather flow (L/capita-day)	Probability *p* that flow is equaled or exceeded)

310	0.019
307	0.080
304	0.23
300	0.38
.	.
.	.
.	.
160	0.84
147	0.99

(a) Find the ratios of the minimum and the maximum flows to the average flow. (b) If the midyear population of the town is 58,600, what are the present minimum, maximum and average flows of the town assuming 10 % probability of occurrence as the criterion for determining flows?

2. Explain different types of population forecasting methods with equation.

Course Outcome 4 (CO4):

1. A horizontal grit chamber of length16m and width 1m is used for grit removal for a particle diameter of 0.3 mm and density 1400 kg/m^3. The wastewater approach velocity carrying the grit particle is 0.3 m/s and the flow rate is 0.15 m^3/s. Check whether the particle will be settled in the grit chamber or not. (Density of wastewater = 1000kg/m^3, viscosity = 0.001 kg/m.s).
2. Determine the % increase in the head loss through the bar screen when 50 % of flow area is blocked off due to the accumulation of coarse solids.

Assume the following conditions:

Approach velocity = 0.6 m/s

Velocity through clean bar screen = 0.9 m/s

Open area for flow through clean bar screen = 0.19 m^2

Head loss coefficient for clean bar screen = 0.7

3. 50 mg/L of alum is added to 50,000 m^3/day of raw water containing 60 mg/L of suspended solids. (a) Assuming that sufficient natural alkalinity is present, estimate the quantity of sludge is produced in kg/day (b) Assuming that the specific gravity of the sludge is 1.04, calculate the sludge produced in m^3/day. Assume that the removal efficiency of the settling basin is 65 %.

Course Outcome 5 (CO5):

1. Derive Langmuir adsorption isotherm with all the assumptions.
2. Explain different methods of effluent disinfection process.
3. Explain the chemistry of chlorination.
4. Explain the following (i) Free chlorine (ii) available chlorine (iii) total residual chloring
5. Explain with the graph, Breakpoint chlorination.

Course Outcome 6 (CO6):

1. Explain the general reaction mechanism of cation and anion exchange resins.
2. Define (i) Selectivity (ii) exchange capacity
3. Explain *electrodialysis membrane* and *pressure membrane* processes.
4. Explain membrane performance characteristics.

5. Explain different types of membranes with examples.

Model Question paper

Name : **Reg. No**

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
FIFTH SEMESTER B. TECH DEGREE EXAMINATION, Month& Year
CHEMICAL ENGINEERING
CHT 395 PHYSICO CHEMICAL METHODS IN ENVIRONMENTAL ENGINEERING
(2019 Scheme)

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

PART A

(Answer all questions. Each question carries 3 marks)

1. List the sources of drinking water.
2. Explain the term coagulation and flocculation.
3. State the physical and chemical characteristics of waste water
4. Briefly explain the effluent standards and their salient features
5. Explain any two methods for the removal of suspended solids.
6. What are the different types of screens used in waste water treatment plant?
7. What are the two types of hardness, the ions causing them and methods to remove them from drinking water?
8. What are the different methods of disinfection?
9. Explain the theory of filtration.
10. Write the fundamentals of adsorption

PART B

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

Module 1

11. a) What is the difference between rapid and slow sand granular filtration design criteria?
    b) Explain the Hydraulics of Flow through Granular Media filter

12. The average flowrate at small municipal waste water treatment plant is 20, 000m3/day. The highest observed peak daily flowrate is 50000m3/day. Design rectangular primary clarifiers with a channel width of 6m(20ft). Use a minimum of two clarifiers. Calculate the scour velocity to determine if settled material will become resuspended. estimate the BOD and TSS removal at average and peak flow. Use an overflow rate of 40m3/m2 -d average flow rate and a slide water depth of 4m (13.1 ft).

Module II

13. Evaluate the significance of physical and chemical treatment in waste water
14. Discuss various advanced methods in treatment of water

Module III

15. Explain the types of aerators with suitable figures. Discuss the purpose and methods of aeration in water treatment.
16. a) What is the design information for aerated flow grit chambers?
b) Design an aerated grit chamber for the treatment of municipal waste water. The average flow rate is 0.1 m^3/s and the peaking factor is 2.75. Determine peak flowrate, grit chamber volume, width to depth ratio (1.2:1), detention time, total air supply requirement, volume grit. assume that the depth, and flowrate are 3m and 0.3m^3/min-m respectively

Module IV

17. Give an account on Ion Exchange Process. Explain its advantages also.
18. Explain various types of chlorination in water treatment? Define break point chlorination and double chlorination

Module V

19. Discuss the working principle, flux equation and applications of ultrafiltration process with neat sketch.
20. a) With suitable sketch explain the basic principle of membrane separation process.
b) What is membrane fouling? State the sources of fouling and remedies (14*5=70)

Syllabus

Module I (10 Hrs.)

Physicochemical Water treatment: Sources of water, physical and chemical quality of water, water quality standards-Significance of physicochemical treatment –Principle and objectives of Physical & chemical treatment units sedimentation processes-types of settlings - tube settlers - design of sedimentation tanks, coagulation and flocculation-coagulation processes; filtration-filtration processes-filter media - types of filters, hydraulics of filtration-filter problems-design of filters

Module II (8 Hrs.)

Physicochemical Wastewater treatment: Wastewater sources, Physical and chemical characteristics of wastewater- Estimation and quantity of wastewater-Flow rate and fluctuations - Effluent standards - variations in concentrations of wastewater constituents-Analysis of mass loadings- treatment sequence-Preliminary, Primary, Secondary, Tertiary, advanced treatment.

Module III (9 Hrs.)

Theory and design of physicochemical unit operations for wastewater: Screening, grit removal Equalization - types of equalization process – volume of equalization basins - Floatation and aerosol separation - methods of floatation-gas particle contact - dissolved air floatation-decarbonation and Softening

Module IV (9 Hrs.)

Adsorption: - adsorption isotherms - adsorption kinetics - factors influencing - design of adsorption units

Disinfection processes: - methods of disinfection - factors influencing - non-chemical methods - details of chlorination - other disinfection processes

Module V (9 Hrs.)

Ion exchange: - process-materials-exchange reactions application in water and wastewater treatment-design of units

Membrane process: - Water softening – Demineralisation - Reverse osmosis - electro-dialysis - ultra filtration - membrane properties and types - process design

Text Books

1. Weber W.J Physicochemical processes for water quality control, John Willy and Sons, New York, 1990
2. Metcalf and Eddy Inc., Wastewater Engineering Treatment Disposal Reuse, Tata McGraw Hill Publishing Company, 2003.
3. Ronald L. Droste, Theory and practice of water and wastewater treatment, John Willy and sons (ASIA) Pvt Ltd, 1997.
4. Mark J Hammer, Mark J Hammer Jr, Water and wastewater technology Prentice Hall of India Pvt Ltd, 2007.
5. Santhosh Kumar Garg, Water supply engineering, Khanna publishers, 1996.
6. Santhosh Kumar Garg, Sewage disposal and air pollution engineering, Khanna publishers, 2008.

Reference Books

1. Nicholas P Cheremisinoff, HANDBOOK OF WATER AND WASTEWATER TREATMENT TECHNOLOGIES, Butterworth-Heinemann Publishers, USA, 2002
2. Arceivala, S.J., Wastewater Treatment for Pollution Control, TMH, New Delhi, Second Edition, 2000.
3. Manual on Sewerage and Sewage Treatment, CPHEEO, Ministry of Urban Development, Govt. of India, New Delhi, 1999.
4. Qasim, S.R. Wastewater Treatment Plant, Planning, Design & Operation, Technomic Publications, New York, 1994.
5. Lawrence K. Wang, Yung-Tse Hung, Nazih K. Shammas, Physicochemical Treatment Processes (HANDBOOK OF ENVIRONMENTAL ENGINEERING-Volume 3), Humana Press Inc. New Jersey 2005

Course Contents and Lecture Schedule

No	Topic	No. of Lectures (Hrs.)
1	**Physicochemical Water treatment: (10 Hrs.)**	
1.1	Sources of water, physical and chemical quality of water, water quality standards	2
1.2	Significance of physicochemical treatment–Principle and objectives of Physical & chemical treatment units	2
1.3	Sedimentation processes -types of settlings - tube settlers - design of sedimentation tanks	2
1.4	Coagulation and flocculation-coagulation processes	1
1.5	Filtration-filtration processes-filter media - types of filters, hydraulics of	2

	filtration	
1.6	Filter problems-design of filters	1
2	**Physicochemical Wastewater treatment: (8 Hrs.)**	
2.1	Wastewater sources, Physical and chemical characteristics of wastewater	1
2.2	Estimation and quantity of wastewater-Flow rate and fluctuations	2
2.3	Effluent standards - variations in concentrations of wastewater constituents	2
2.4	Analysis of mass loadings	1
2.5	Treatment sequence-Preliminary, Primary, Secondary, Tertiary, advanced treatment	2
3	**Theory and design of physicochemical unit operations for wastewater (9 Hrs.)**	
3.1	Screening	1
3.2	Grit removal	2
3.3	Equalization - types of equalization process – volume of equalization basins	2
3.4	Floatation and aerosol separation	1
3.5	Methods of floatation-gas particle contact	1
3.6	Dissolved air floatation	1
3.7	Recarbonation and Softening	1
4	**Adsorption and Disinfection processes**: **(9 Hrs.)**	
4.1	Adsorption isotherms	2
4.2	Adsorption kinetics - factors influencing	1
4.3	Design of adsorption units	2
4.4	Methods of disinfection	1
4.5	Factors influencing - non-chemical methods	1
4.6	Details of chlorination	1
4.7	Other disinfection processes	1
5	**Ion exchange and Membrane process: (9 Hrs.)**	
5.1	Ion exchange process-materials	1
5.2	Ion exchange reactions application in water and wastewater treatment	1
5.3	Design of Ion exchange units	1
5.4	Water softening – Demineralisation	1
5.5	Reverse osmosis - electro-dialysis	2
5.6	Ultra-filtration - membrane properties and types	2
5.7	Process design	1

CHT397	SOFT COMPUTING TECHNIQUES	CATEGORY	L	T	P	CREDIT
		VAC	3	1	0	4

Preamble: This course gives an introduction to some new fields in soft computing with its principal components of fuzzy logic, NN, GA and Fuzzy genetic hybrid systems.

Pre-requisite: Nil

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

CO 1	Explain the concepts involved in fuzzy logic systems.
CO 2	Design fuzzy logic controllers for various applications
CO 3	Train neural networks for various applications
CO 4	Solve optimisation problems using Genetic Algorithms
CO 5	Understand the concepts of Hybrid Soft computing techniques.

Mapping of course outcomes with program outcomes

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

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	10
Understand	20	20	20
Apply	20	20	70
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

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

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

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Explain the features of fuzzy membership functions with proper diagrams.
2. Discuss fuzzy equivalence relations and list out its properties?
3. For the fuzzy sets A = $\{0.2/x_1 + 0.9/x_2\}$ and B = $\{0.3/y_1 + 0.5/ y_2 + 1/y_3\}$, find the fuzzy relation A×B

Course Outcome 2 (CO2)

1. Defuzzify the following output membership function using centroid method:
   0/0, 0.3/1, 0.3/3.5, 0.5/4, 0.5/5.5, 1/6, 1/7, 0/8.
2. Explain any five defuzzification methods.

Course Outcome 3(CO3):

1. List the stage involved in Back Propagation Algorithm?

Course Outcome 4 (CO4):

1. Explain different types of Encoding Techniques.

Course Outcome 5 (CO5):

1. Explain the characteristics and different classifications of a neuro-fuzzy hybrid system.

Model Question paper

Name :Reg.No.

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
FIFTH SEMESTER B. TECH DEGREE EXAMINATION,
Month& Year
CHEMICAL ENGINEERING
CHT 397 Soft Computing Techniques
(2019 Scheme)

Duration: 3hours   Max. Marks: 60

PART A

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

1. Distinguish between fuzzy and probability with example.
2. State the relevance of fuzzification. Explain different types.
3. What is unsupervised learning in ANN? Explain
4. Explain any training algorithm that can be used for training a multilayer feed forward neural network.
5. Explain radial basis function network.
6. State the significance of error portion $^{\delta}$kand $^{\delta}$jin Back Propagation Network.
7. What is the concept of crossover in Genetic Algorithm?
8. Write short note on application of GA.
9. Explain Genetic Neuro - Hybrid systems
10. Discuss the classification of Neuro Fuzzy Hybrid System?

PART B

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

Module 1

11. a) If membership functions A is {1/2 +0.5/3 + 0.6/4 + 0.2/5 + 0.6/6} and B is {0.5/2 + 0.8/3+0.4/4+0.7/5 + 0.3/6} find A/B and B/A (4 marks)

b) Two triangular membership functions are given as A = triang(1,3,4) and B=triang(3,5,6). Draw membership functions of A ∩ B, A U B and A'. (5 marks)

c) For the fuzzy sets A = $\{0.2/x_1 + 0.9/x_2\}$ and B = $\{0.3/y_1 + 0.5/ y_2 + 1/y_3\}$, find the fuzzy relation A×B (5 marks)

12. a) Using the intuition method develop fuzzy membership functions for the following shapes. (a) Trapezoid. (b) Gaussian function. (c) Isosceles triangle. (4 marks)

b) Define Fuzzy Propositions. Explain different fuzzy propositions. (10 marks)

Module II

13. a)Defuzzify the following output membership function using centroid method:
0/0, 0.3/1 , 0.3/3.5 , 0.5/4 , 0.5/5.5 , 1/6 , 1/7 , 0/8. (4 marks)

b) In the following fuzzy system to predict power demand of a state, the following input membership functions are used:

Temperature :triang(0 10 20), triang(10 25 40), triang(30 40 50). (for low, medium and high)
Month :triang(0 2 4), triang(2 6 10), triang(8 10 12), (for summer, rainy and winter)
The oputput membership function is

Power demand :triang(0 250 400), triang(250 500 750), triang(600 750 1000), (for low, medium and high)

The rules are

1) If temp is low and month is winter, demand is low
2) If temp is medium and month is rainy, demand is medium
3) If temp is medium and month is winter, demand is high.

For a temperature of 16 and for a month of 9.5, find the power demand using centroid defuzzification method. (5 marks)

c) Do problem 2b using weighted average defuzzification method. (5 marks)

14. a) Explain any five defuzzification methods. (5 marks)

b) What are the different steps involved in the design of fuzzy logic controller? Explain with a typical example. (9 marks)

Module III

15. a) A perceptron is used to classify the inputs and targets mentioned below:
{ p1 = [1;1], t1 =[0;0]}, {p2 = [1;2], t2 = [0;0]}, { p3 = [2;-1], t3 = [0;1]}, p4 = [2;0], t4 = [0;1]},
{p5= [[-1;2], t5 =[1 0]}, {p6=[-2;1], t6=[1;0]}, {p7=[-1;-1], t7=[1;1], {p8 = [-2;-2], t8=[1;1]}

Train the network with the initial weight and bias matrices of [1 0;0 1] and [1;1] respectively. (4 marks)

b) A 1-2-1 network with log sigmoid transfer function in the hidden layer and linear transfer function in the output layer is used to model a function which gives an output value of 1.261 for an input of 1. For the initial weight and bias matrices

$$\mathbf{W}^1(0) = \begin{bmatrix} -0.27 \\ -0.41 \end{bmatrix},\ \mathbf{b}^1(0) = \begin{bmatrix} -0.48 \\ -0.13 \end{bmatrix},\ \mathbf{W}^2(0) = \begin{bmatrix} 0.09 & -0.17 \end{bmatrix},\ \mathbf{b}^2(0) = \begin{bmatrix} 0.48 \end{bmatrix}$$

of

find the weight and biases after one iteration of back propagation. (5 marks)

c) Realize an Exclusive-OR gate using a combination of Perceptron neurons. (5 marks)

16. a) State the significance of error portion δkand δjin Back Propagation Network. (5 marks)

b) Explain the stage involved in Back Propagation Algorithm? (9 marks)

Module IV

17. a) Draw the flow chart of Genetic Algorithm based optimization process and enlist the steps involved and the methods available in each step. (4 marks)

b) Do one iteration of finding the maximum of the following function using Genetic Algorithm:

Maximize $Y = 800 - 62.83(2D + 0.91D^{-0.2})$, $0 < D < 6.3$

Choose (0.3, 1.5, 3, 5) as initial population and make 5th position in single point crossover. Do mutations at 5th, 17th and 23rd positions. (5 marks)

c) It is required to solve the equation a+2b+3c+4d = 30 after converting this to a maximization problem using Genetic Algorithm. Do one iteration. (5 marks)

18. a) Explain various coding techniques in GA with examples? (5 marks)

b) Explain Genetic Fuzzy Rule Based systems? (9 marks)

Module V

19. a) Explain the use of Genetic Algorithm in training a neural network (4 mark)

b) Explain how the performance of a PI controller can be improved with fuzzy system. (5 marks)

c) Explain the concept of Neuro Genetic Systems (5 marks)

20. a) Explain the characteristics and different classifications of a neuro-fuzzy hybrid system. (10 marks)

b) Explain Genetic Fuzzy Rule Based systems? (4 marks)

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Syllabus

Module 1

Introduction to fuzzy logic: Fuzzy Sets-Fuzzy set operations-Fuzzy Relations-Cardinality of fuzzy relations-operations on Fuzzy Relations-Properties of Fuzzy relations-properties of fuzzy relations-Membership functions-features of membership functions-Fuzzification-methods of membership value assignments-fuzzy rule base

Module 2

Defuzzification-Defuzzification methods-Fuzzy logic controller (Block diagram).artificial neural networks. Basic concepts-Neural network architecture-Single layer feed forward network-Multilayer feed forward network-Recurrent networks

Module 3

Characteristics of Neural networks- Learning methods. Perceptron networks-Back propagation networks-Radial base function network-Hopfield network-Kohonenself-organising maps.

Module 4

Fundamentals of genetic algorithms: Basic concepts-working principle-encoding-different methods-fitness function-reproduction-different methods. Genetic modelling- inheritance-cross over mutation-convergence of genetic algorithm.

Module 5

Hybrid systems: Neural network, fuzzy logic and genetic algorithm hybrids-Neuro fuzzy hybrids-neuro genetic hybrids-Fuzzy genetic hybrids.

Text Books:

1. S. Haykins, *Neural networks a comprehensive foundation*, Pearson Education.
2. L. Fausett, *Fundamentals of Neural Networks*, Prentice Hall 1994.
3. Timothy J Ross, *Fuzzy Logic with Engineering Applications*, McGrawHill, New York.

Reference Books

1. S. N. Sivanandam, S. N. Deepa, *Principles of Soft Computing*, Wiley India Pvt. Ltd.
2. S. Rajasekharanand and G.A. VijayalakshmiPai, Neural Network, *Fuzzy Logic and Genetic Algorithms- Synthesis and Applications*, Prentice Hall of India.
3. D.E. Goldberg, *Genetic Algorithms in search Optimization and Machine Learning*, Pearson Education.
4. AmitKonar, *Artificial Intelligence and Soft Computing*, First Edition,CRC Press, 2000.
5. John Yen, Reza Lengari, Fuzzy Logic- Intelligence, Control and Information, Pearson Education.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures (Hrs.)
1	**Fuzzy logic (9 Hrs)**	
1.1	Introduction to fuzzy logic: Fuzzy Sets-Fuzzy set operations	2
1.2	Fuzzy relations-Cardinality of fuzzy relations-operations on Fuzzy Relations-Properties of Fuzzy relations-properties of fuzzy relations-	3
1.3	Membership functions-features of membership functions	2
1.4	Fuzzification-methods of membership value assignments-fuzzy rule base	2
2	**Defuzzification (9 Hrs)**	
2.1	Defuzzification methods	2
2.2	Fuzzy logic controller (Block diagram).	2
2.3	Artificial neural networks. Basic concepts	2
2.4	Neural network architecture-Single layer feed forward network-Multilayer feed forward network-Recurrent networks	3
3	**Characteristics of Neural networks (9 Hrs)**	
3.1	Characteristics of Neural networks- Learning methods.	2
3.2	Perceptron networks-Back propagation networks	2
3.3	Radial base function network-Hopfield network	3
3.4	Kohonen self-organising maps	2
4	**Fundamentals of genetic algorithms (10 Hrs)**	
4.1	Fundamentals of genetic algorithms- Basic concepts-working principle	2
4.2	Encoding-different methods	2
4.3	Fitness function-reproduction-different methods.	3
4.4	Genetic modelling- inheritance-cross over mutation-convergence of	3

	genetic algorithm.	
5	**Hybrid systems (8 Hrs)**	
5.1	Hybrid systems: Neural network, fuzzy logic and genetic algorithm hybrids	3
5.2	Neuro fuzzy hybrids-neuro genetic hybrids	3
5.3	Fuzzy genetic hybrids.	2

SEMESTER VI

CHT 302	MASS TRANSFER OPERATIONS - II	CATEGORY	L	T	P	CREDIT
		PCC	3	1	0	4

Preamble: Objective of this course is to impart fundamental concepts of mass transfer operations such as distillation, liquid extraction, leaching and membrane separation processes. This course also explains how to quantify, formulate, and solve engineering problems involving different mass transfer operations like distillation, liquid-liquid extraction, leaching and membrane separation processes.

Prerequisite: Basic knowledge in Chemical Process Principles

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

CO1	Explain boiling point diagrams, relative volatility and differentiate various types of distillation techniques.
CO2	Design a fractionation column using McCabe – Thiele method and apply it for various reflux conditions.
CO3	Apply Ponchon - Savarit method to determine the number of stages required for a given separation in a fractionator for different reflux conditions and to understand rectification in packed columns.
CO4	Explain the theory of extraction and design of single stage and multi-stage extraction processes with an understanding of construction and working of extractors.
CO5	Explain the theory of leaching and design of single stage and multi-stage leaching processes with an understanding of construction and working of leaching equipments.
CO6	Differentiate among various types of membrane separation processes.

Mapping of course outcomes with program outcomes

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

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	20
Understand	10	10	20
Apply	20	20	40
Analyze	10	10	20
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

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

End Semester Examination Pattern:

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

Course Level Assessment Questions

Course Outcome 1 (CO1): Explain boiling point diagrams, relative volatility and differentiate various types of distillation techniques.

1. Define relative volatility and explain its significance.
2. Define Differential distillation and derive the material balance equation for differential distillation.
3. Show that the relative volatility of an ideal binary system is equal to the ratio of vapor pressure of two components.

Course Outcome 2 (CO2): Design a fractionation column using McCabe – Thiele method and apply it for various reflux conditions.

1. A continuous distillation column is to separate 50 kmol/hr of feed mixture having 65% Benzene (A) and 35% Toluene (B). Top product contains 95% Benzene and Bottom product contains 95% Toluene (by mole). Feed is saturated liquid at its bubble point.

Average relative volatility is 2.44. If reflux ratio R= 2.25 R_{min}, determine feed tray location and number of theoretical stages by McCabe -Thiele method.

2. Define reflux ratio. Explain how to calculate the minimum reflux ratio when feed is a saturated vapour.
3. Define constant molal overflow. Outline the McCabe-Thiele design method for obtaining number of theoretical trays by graphical method clearly mentioning its assumptions.

Course Outcome 3 (CO3): Apply Ponchon - Savarit method to determine the number of stages required for a given separation in a fractionator for different reflux conditions and to understand rectification in packed columns.

1. Explain the various steps in determining number of stages in a distillation column by Ponchon - Savarit method
2. Explain the concept of net flow and difference point
3. Explain extractive distillation with the help of an example.

Course Outcome 4 (CO4): Explain the theory of extraction and design of single stage and multi- stage extraction processes with an understanding of construction and working of extractors.

1. Nicotine in a water solution containing 1% nicotine is to be extracted with kerosene at 25^0C. Kerosene and water are insoluble. Determine the percentage extraction of nicotine if 1000 kg of feed solution is extracted in a single stage operation using 1500 kg solvent. What would be the percentage extraction if three theoretical stages are used with 500 kg solvent in each stage? Equilibrium data expressed as kg nicotine/ kg liquid are as follows:

X	0.001	0.0025	0.005	0.0075	0.00998	0.0204
Y	0.0008	0.00196	0.0046	0.0069	0.0091	0.0187

2. Explain different factors to be considered for selection of solvent in extraction operations.
3. Explain the principle and working of mixer settler cascade

Course Outcome 5 (CO5): Explain the theory of leaching and design of single stage and multi-stage leaching processes with an understanding of construction and working of leaching equipments.

1. Oil seed containing 20% oil is extracted in counter current plant and 90% of the oil is recovered to get a solution containing 50% oil. If the seeds are extracted with fresh solvent and 1kg solution is removed in the underflow in association with every 2kg of insoluble matter. Determine the number of ideal stages required.
2. Discuss the factors affecting leaching.
3. List out the applications of leaching.

Course Outcome 6 (CO6): Differentiate among various types of membrane separation processes.

1. What are the advantages of membrane separation processes over conventional separation processes?

2. Enlist the factors affecting membrane performance.
3. Write a note on ultrafiltration.

****

Model Question Paper

QP CODE: **PAGES: 3**

Reg No: _______________Name: _______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SIXTH SEMESTER B. TECH DEGREE EXAMINATION,MONTH & YEAR

Course Code: CHT302

Max. Marks: 100 Duration: 3 Hours

MASS TRANSFER OPERATIONS - II

PART – A

Answer All the Questions (10 x 3 = 30)

1. The relative volatility of a binary system is 4.13. Find out x – y data.
2. Derive Rayleigh equation for a binary mixture.
3. Define reflux ratio and differentiate between minimum reflux ratio and total reflux ratio.
4. Derive q-line equation for feed tray location.
5. Differentiate between Packed Towers and Tray Towers.
6. Define selectivity of solvent used in liquid extraction.
7. Explain briefly the system of three liquids with one pair partially soluble in case of liquid extraction.
8. List out the various factors which limit the rate of solid-liquid extraction.
9. Write a short note on heap leaching.
10. Outline the industrial applications of leaching.

PART – B

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

Module 1

11. (a) A liquid mixture containing 40 mole percent of n-heptane and 60% n-octane (α = 2.16) is subjected to differential distillation at atmospheric pressure with 60% (mole) of the liquid distilled. Compute the composition of the Distillate and Residue.
    (b) A fractionation column has been installed to distillate 5000 kg/hr of a mixture of 50 % methanol & 50% water (by weight). The overhead and bottom products are found to contain 95 % methanol and 1 % methanol respectively. Carry out material balances.
    Data: Mol. wt. of methanol: 32 and Mol. wt. of water: 18. **(7+7 = 14 Marks)**

OR

12. (a) Define relative volatility and explain its significance.

(b) Define Differential distillation and derive the material balance equation for differential distillation.

(c) Show that the relative volatility of an ideal binary system is equal to the ratio of vapor pressure of two components. **(3+6+5 = 14 Marks)**

Module II

13. (a) Derive Fenske's equation for the minimum number of theoretical stages.

(b) Define reflux ratio. Explain how to calculate the minimum reflux ratio when feed is a saturated vapour. **(7+7 = 14 Marks)**

OR

14. A continuous distillation column is to separate 50 kmol/hr of feed mixture having 65% Benzene (A) and 35% Toluene (B). Top product contains 95% Benzene and Bottom product contains 95% Toluene (by mole). Feed is saturated liquid at its bubble point. Average relative volatility is 2.44. If reflux ratio R= 2.25 R_{min}, determine feed tray location and number of theoretical stages by McCabe -Thiele method. **(14 Marks)**

Module III

15. (a) Define an azeotrope. Explain the advantages, disadvantages and industrial application of azeotropic distillation with suitable example.

(b) Explain the concept of net flow and difference point **(8+6 =14 Marks)**

OR

16. Explain the various steps in determining number of stages in a distillation column by Ponchon - Savarit method. **(14 Marks)**

Module IV

17. (a) Explain with neat sketches any two extraction equipments used in chemical industries.

(b) Explain different factors to be considered for selection of solvent in extraction operations. **(8+6 = 14 Marks)**

OR

18. Nicotine in a water solution containing 1% nicotine is to be extracted with kerosene at 25 0C. Kerosene and water are insoluble. Determine the percentage extraction of nicotine if 1000 kg of feed solution is extracted in a single stage operation using 1500 kg solvent.Calculate the percentage extraction if three theoretical stages are used with 500 kg solvent in each stage. Equilibrium data expressed as kg nicotine/ kg liquid are as follows:

X	0.001	0.0025	0.005	0.0075	0.00998	0.0204
Y	0.0008	0.00196	0.0046	0.0069	0.0091	0.0187

(14 Marks)

Module V

19. (a) Explain the working of Shank's system in detail with schematic diagram.

(b) Enlist the advantages of membrane separation processes over conventional separation processes. **(7+7 = 14 Marks)**

OR

20. (a) Oil seed containing 20% oil is extracted in counter current plant and 90% of the oil is recovered to get a solution containing 50% oil. If the seeds are extracted with fresh solvent and 1kg solution is removed in the underflow in association with every 2kg of insoluble matter. Determine the number of ideal stages required.
(b) Enlist the factors affecting membrane performance. **(9+5 = 14 Marks)**

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Syllabus

Module 1 (8 Hrs.)

Distillation- Vapour-Liquid Equilibria, boiling- point diagram and equilibrium curves, relative volatility, application of Raoult's law. Distillation methods- flash distillation, Simple distillation or Differential distillation, Binary distillation, Steam distillation, Problems.

Module 2 (10 Hrs.)

Fractionation of binary mixtures, Principle of fractionation, Fractionation in plate columns, condensers and reboilers. Material and energy balance, Design of fractionation columns by McCabe - Thiele method - basic assumptions, feed quality and feed line, number of plates, feed plate location, total reflux, minimum reflux , optimum reflux, plate efficiency, cold reflux and open steam.

Module 3 (8 Hrs.)

Enthalpy composition diagrams, Concept of net flow and difference point, Ponchon–Savarit method– material and enthalpy balance, number of plates, feed plate location, minimum reflux conditions. Rectification in packed columns, height of packed towers.
Azeotropic and Extractive distillation (qualitative treatment only).

Module 4 (10 Hrs.)

Extraction –applications, ternary equilibria on triangular coordinate system,mixer rule, distribution curve, selectivity, choice of solvent. Single-stage and multistage extraction operations - Calculations for immiscible systems and partially miscible systems.
Construction and working of mixer -settler cascades, sieve-tray columns, agitated towers, pulse columns and centrifugal extractors.

Module 5 (9 Hrs.)

Leaching – Rate of leaching, factors affecting rate of leaching. Working principles of leaching equipment- Shank's system- thickeners, classifiers and moving bed leaching equipment.
Leaching equilibrium - constant underflow - variable underflow Single stage and multistage leaching.
Membrane separation processes – classification – types of membranes: flat, spiral wound, hollow fibre -concentration polarization – ultrafiltration.

Text Books:

1. Treybal R.E., Mass Transfer Operations, McGraw Hill.
2. Binay K Dutta, Principles of Mass Transfer & Separation Processes, PHI Learning Private Limited.

Reference Books:

1. K.V. Narayanan and B. Lakshmikutty.Mass Transfer-Theory and Applications,CBS Publishers.
2. N. Anantharaman and K.M.Meera Sheriffa Begum, Mass Transfer-Theory and Practice, PHI Learning Private Limited (2011) New Delhi.
3. McCabe W.L., Smith J.C. &Harriot P., Unit Operations in Chemical Engineering, McGraw Hill.
4. Geankoplis C.J., Transport Processes and Unit Operations, Prentice Hall India
5. Coulson J.M. & Richardson J.F., Chemical Engineering, Vol. II, ELBS, Pergamon

Course Contents and Lecture Schedule:

No.	Details	No. of Lectures
1	**Module 1**	**8**
1.1	Introduction to distillation, Vapor-liquid equilibrium, T-x-y diagram, bubble and dew point calculations	2
1.2	Relative volatility, equilibrium curves - application of Raoult's law	1
1.3	Ideal and non -ideal solutions, azeotropes	1
1.4	Batch distillation and equilibrium flash vaporization	2
1.5	Steam distillation	1
1.6	Differential distillation	1
2	**Module II**	**10**
2.1	Fractionation - plate columns for distillation –condensers – reboilers	1
2.2	Principles of rectification - material and energy balance	1
2.3	Design of fractionation columns by McCabe - Thiele method - basic assumptions - feed quality and feed line	1
2.4	Design of fractionation columns by McCabe - Thiele method - number of plates- feed plate location.	2
2.5	Design of fractionation columns by McCabe - Thiele method - number of plates - total reflux&minimum reflux.	2
2.6	Design of fractionation columns by McCabe - Thiele method - number of plates - optimum reflux, plate efficiency.	2
2.7	Design of fractionation columns by McCabe - Thiele method - cold reflux, open steam.	1
3	**Module III**	**8**
3.1	Enthalpy – composition diagrams, Ponchon–Savarit method– difference points and reflux ratio	2
3.2	Ponchon–Savarit method - number of plates, feed plate location,	3

	minimum reflux conditions.	
3.3	Rectification in packed columns - height of packed towers	2
3.4	Azeotropic and extractive distillation (qualitative treatment only).	1
4	**Module IV**	**10**
4.1	Extraction - applications - ternary equilibria on triangular coordinate system, single stage extraction	2
4.2	Mixer rule -distribution curve – selectivity, choice of solvent	1
4.3	Single-stage and multistage extraction operations - Calculations for immiscible systems.	2
4.4	Single-stage and multistage extraction operations - Calculations for partially miscible systems.	3
4.5	Construction and working of mixer - settler cascades, sieve-tray columns, agitated towers, pulse columns and centrifugal extractors.	2
5	**Module V**	**9**
5.1	Leaching -factors affecting rate of leaching. Leaching equilibrium - constant underflow - variable underflow Single stage and multistage leaching.	4
5.2	Working principles of leaching equipment- Shank's system- thickeners, classifiers and moving bed leaching equipment.	2
5.3	Membrane separation processes – classification – types of membranes: flat, spiral wound, hollow fibre -concentration polarization – ultrafiltration.	3

CHT304	TRANSPORT PHENOMENA	CATEGORY	L	T	P	CREDIT
		PCC	3	1	0	4

Preamble: This course introduces coupling between three transport phenomena, momentum, heat and mass transport with applications in various disciplines in engineering and science, and will demonstrate to the students the common mathematical structure of transport problems. The course will deal with flow problems involving Newtonian and non-Newtonian fluids, solid-state heat conduction and convection, binary diffusion with or without chemical reaction. To give basic axioms of conservations namely conservation of momentum, energy and mass

Prerequisite: Basic knowledge in calculus, momentum, heat and mass transfer

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

CO 1	Explain the mechanisms of momentum, heat and mass transfer
CO 2	Predict the transport coefficients of gases from basic physical variables
CO 3	Solve industrial problems involving isothermal steady state momentum transfer in simple geometries using shell momentum balance , equations of change and boundary conditions
CO 4	Obtain analytical solutions of selected simple engineering steady state problems of heat transfer using shell energy balance and equations of change
CO 5	Analyze simple steady state diffusion problems using shell mass balance

Mapping of course outcomes with program outcomes

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

Assessment Pattern

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

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

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

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

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Explain the mechanism of momentum transfer between two parallel plates in which one is moving and the other stationary.
2. Prove that the sum of the molar diffusion fluxes relative to the molar average velocity is zero in any mixture.
3. Explain the analogies among transport mechanisms.

Course Outcome 2 (CO2)

1. For gases at low density, viscosity increases with increase in temperature, justify the statement.
2. Using Chapman-Enskog formula compute the thermal conductivity of neon at 1atm and 373.2K. Given: Lennard-Jones characteristic diameter of the neon molecule=2.789^{o}A, molecular weight of neon molecule=20.183. Collision function $\Omega_{\mu}=\Omega_{k}=0.821$.
3. What bulk properties are related to Stokes – Einstein equation? Check the dimensional consistency of equation.

Course Outcome 3(CO3):

1. A fluid of constant density and viscosity is in a cylindrical container of radius R .The container is caused to rotate about its own axis (vertical) at an angular velocity **Ω**. Find the shape of the free surface at steady state.

2. Write the Navier-Stokes equation. Under what conditions equation of motion for Newtonian fluids reduces to Navier-Stokes equation.
3. Sketch the momentum flux and velocity distributions for the flow through cylindrical tubes.

Course Outcome 4 (CO4):

1. Derive expression for temperature profile for the flow of incompressible Newtonian fluid between 2 co-axial cylinders, in which the outer cylinder rotates and inner one is held stationary.

2. A heated sphere of radius R is suspended in a large, motionless body of fluid. It is desired to study the heat conduction in the fluid surrounding the sphere in the absence of convection.

   (a) Set up the differential equation describing the temperature T in the surrounding fluid as a function of r, the distance from the center of the sphere. The thermal conductivity k of the fluid is considered constant.

   (b) Integrate the differential equation and use these boundary conditions to determine the integration constants: at $r = R$, $T = T_R$; and at $r = \infty$, $T = T_\infty$.

   (c) From the temperature profile, obtain an expression for the heat flux at the surface. Equate this result to the heat flux given by "Newton's law of cooling" and show that a dimensionless heat transfer coefficient (known as the Nusselt number) is given by $Nu = \frac{hD}{k} = 2$,in which D is the sphere diameter

3. Derive expressions for heat flux, temperature distribution and average temperature rise at steady state in an electrical wire of circular cross section. The rate of heat production per unit volume is given by $Se=I^2/K_e$. I is the current density amperes/cm2 and k_e is the electrical conductivity ohm^{-1} cm^{-1}. Assume that the outer surface of the conductor is maintained at constant temperature. Also find the heat out flow from the surface.

Course Outcome 5 (CO5):

1. A gaseous phase reaction $2A \rightarrow A_2$ is taking place on the surface of a catalyst. Assume that each catalyst particle is surrounded by a stagnant gas film through which A has to diffuse to reach catalyst. Using suitable assumptions develop an expression for the local rate of conversion and obtain the concentration profile in the gas film and molar flux through the film. Sketch the concentration profile.

2. Diffusivity of a gas pair O_2-CCl_4 is determined by observing the steady state evaporation of CCl_4 into a tube containing O_2. The distance between CCl_4 liquid level and the top of the tube is 17.1cm. The total pressure on the system is 755mmHg and temperature is 273K.The vapour pressure of CCl_4 at that temperature is 33 mmHg. The cross sectional area of diffusion tube is $0.82cm^2$. It is found that $0.0208cm^3$ of CCl_4 evaporate in a 10hr period after steady state has been achieved. What will be diffusivity of gas pair CCl4-O2. Given that density of CCl4=1.59g/cm3.

3. Derive the equation of continuity for a binary mixture.

Model Question Paper

QP CODE: **PAGES: 3**

Reg No: _______________Name: _______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SIXTH SEMESTER B. TECH DEGREE EXAMINATION,MONTH & YEAR

Course Code: CHT 304

Max. Marks: 100 Duration: 3 Hours

TRANSPORT PHENOMENA

PART – A

Answer **all** questions. Each question carries **3** marks

1. Compute the viscosity of CO2 at 200K and 1 atm. Given $\Omega\mu$ =1.548, σ =3.996A°.
2. Describe the relationship between thermal conductivity and viscosity of gases.
3. An oil has a kinematic viscosity of 2x10-4 m^2 /s and a density of 0.8x103 kg/m3. If we want to have a falling film of thickness of 2.5 mm on a vertical wall, what should the mass rate of flow of the liquid be?
4. Give the vector form of the Navier-stokes and Euler equations and explain the significance of each term.
5. The maximum temperature rise in a current carrying conductor is $I^2 R^2 /4kk_e$ .Obtain the following equation representing the relationship between the voltage drop E and the maximum temperature rise within a current carrying conductor of radius R, current density I, length L, thermal conductivity k and electrical conductivity k_e. $E = 2\frac{L}{R}\sqrt{\frac{k}{keT_0}}\sqrt{T_0(T_{max} - T_0)}$. Here T_0 and T_{max} are the surface temperature and centre temperature of the wire.
6. What is transpiration cooling? and give applications of transpiration cooling.
7. Write the different types of concentrations, velocities and fluxes used to describe diffusion in a multi-component mixture.
8. Explain the conservation equation used in momentum, energy and mass transport.
9. State the procedure to solve steady state mass transfer problem using shell momentum balance and list the important boundary conditions used to solve it.
10. Explain briefly about the diffusion of component ‘A’ through a stagnant “B’ within the liquid vapour interface maintained at a fixed position and obtain an expression for the molar flux of component A.

(10x3=30 marks)

PART B

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

MODULE-I

11. (a) Estimate the viscosity of N2 at 50°C and 854 atm. Given M=28,Pc =33.5 atm; Tc = 126.2K and μr =2.39. Also calculate Tr and Pr. **(4)**

(b) Establish a correlation for gas viscosity with temperature and pressure using kinetic theory of gases. List valid assumptions. **(10)**

OR

12. (a) Compute the thermal conductivity of argon at 80° C and 1 atm pressure using Chapman-Enskog model. The molecular weight of argon is 39.54, σ =3.4180 A° and Ω_k =1.039. **(4)**

(b) Calculate the thermal conductivity of a mixture containing 20 mol% CO_2 and 80 mol% H_2 at 1 atm and 300K. Given

	Thermal Conductivity(Cal/s.cm.K)	Viscosity(g/s.cm)
CO2	$383x10^{-7}$	$1495x10^{-7}$
H2	$4250x10^{-7}$	$896x10^{-7}$

(10)

MODULE-II

13. Derive the momentum flux and velocity distribution, average velocity and volumetric flow rate equations for a laminar fluid flowing through an annulus of inner radius KR, outer radius R and length L. **(14)**

OR

14. Determine the velocity and shear stress distribution for the tangential laminar flow of an incompressible fluid between two vertical coaxial cylinders. The outer one is rotating with an angular velocity $\Omega_{0.}$ Also determine the viscosity of the fluid. **(14)**

MODULE-III

15. Consider a spherical form of nuclear fissionable material of radius R^F and is surrounded by aluminium cladding of radius R^C .The purpose of cladding is to absorb neutrons. Inside the fuel element ,due to fission thermal energy is produced (S_n).This source will not be uniform throughout the sphere of fissionable material, it will be smallest at the centre of the sphere. Therefore source is assumed as a parabolic function. Sn = Sn_0 [1+b(r/ R^F)^2], where Sn_0 is the volume rate of production at the centre of the sphere, b-dimensionless constant. Derive the expression for temperature distribution in the aluminium cladding and fissionable material. **(14)**

OR

16. Determine the temperature distribution in an incompressible Newtonian fluid held between two co-axial cylinders, the outer of which is rotating at a steady angular velocity Ω_0. The inner cylinder has a radius of kR and that of the outer cylinder is R. Consider that the wetted surfaces of the outer and inner cylinders are at temperature T_0 and T_i .Assume steady laminar flow and neglect the temp. dependence of μ,ρ and k.

(14)

MODULE-IV

17. (a) Predict the value of D_{AB} for the system CO-CO_2 at 296K and 1 atm total pressure. Given , Ω_{DAB}=1.067, σ_{AB}=3.793A^0 . **(4)**

(b) For a binary mixture of A&B using the basic definitions of concentrations, velocities and fluxes, show that the mass fraction 'w_A' is related to mole fraction 'x_A' by

(i) $w_A = \frac{x_A M_A}{x_A M_A + x_B M_B}$ (ii) $dw_A = \frac{M_A M_B \, dx_A}{(x_A M_A + x_B M_B)^2}$

(iii) $dx_A = \frac{dw_A}{M_A M_B \left({w_A}/{M_A} + {w_B}/{M_B} \right)^2}$ (iv) $n_A + n_B = \rho V$

Where, n_A, n_B : mass flux relative to fixed spatial co-ordinates

ρ : Density

V : Mass average velocity

M_A , M_B : Molecular weights o A &B respectively

(10)

18. Explain the theory of diffusion of liquid and establish the correlation developed by Wilke and Chang for diffusivity estimation. Also calculate the liquid diffusion coefficient of ethanol in a dilution solution of water at 10oC. The molecular volume of ethanol is 59.2 cm3/gmol. Use of the following data: μ of ethanol at 10oC= 1.45 Cp. The association parameter for water is 2.6.

(14)

MODULE-V

19. A liquid droplet A of radius 'r_1' is evaporating into an isothermal film of gas B surrounding the liquid. The outer surface of the gas film is at a distance 'r_2' from the centre of the liquid droplet. Assume that the concentration of 'A' in terms of mole fraction of A at the liquid-gas interface and at the outer surface of the gas film are constant at x_{A1} and x_{A2} respectively. Assume that gas 'B' does not dissolve in the liquid. Use suitable assumptions and develop mass balance equations and obtain the concentration profile of 'A' in the gas film and also the molar flux of 'A' at the gas-liquid interface and rate of evaporation of liquid. **(14)**

OR

20. A slow catalytic dimerization reaction, 2A → B is taking place on the surface of a catalyst inside a catalytic reactor. The effective gas film thickness on the catalyst surface may be taken as ' δ'. Starting from a mass balance, develop the expressions for the concentration profile of the component A and the molar flux of A through the gas film. Using suitable assumptions. **(14)**

Syllabus

Module 1 (7hrs)

Prediction of transport coefficients – viscosity and thermal conductivity. Viscosity and the mechanisms of momentum transfer: Generalization of Newton's law of viscosity, pressure and temperature dependence of viscosity of gases and liquids, prediction of viscosity of gases: Rigid sphere model and rigorous models, Numerical problems.

Energy Transport: Thermal conductivity and the mechanism of energy transport- prediction of thermal conductivity of gases, effect of temperature and pressure on thermal conductivity of gases, relationship between thermal conductivity and viscosity of gases. Thermal conductivity of solids, relationship between thermal and electrical conductivity of solids, Numerical problems.

Module 2 (12hrs)

Shell momentum balance - boundary conditions - application of shell balance to simple flow systems - falling film -flow of a Newtonian fluid in between two slits formed by two flat plates flow through tube - flow through annulus - flow of two adjacent immiscible fluids. General transport equations for momentum - derivation of continuity equation and equation of motion in rectangular coordinates - NavierStoke's equation and Euler equation - transport equations in curvilinear coordinates (no derivation) - application of transport equations to steady flow problems - flow through tube - tangential annular flow - rotating liquid - cone and plate viscometer.

Module 3 (11 hrs)

Shell energy balance - boundary conditions - application of shell balance to heat conduction problems - conduction with electric, nuclear and viscous heat sources and other similar heat conduction problems, use of shell heat balances in variable thermal conductivity systems to derive temperature and heat flux profiles, cooling fins with insulated tip condition. Equations of energy in rectangular and curvilinear coordinates (no derivation) - application to steady-state heat transfer problems - tangential flow in annulus with viscous heat generation - flow of nonisothermal film - transpiration cooling

Module 4 (7hrs)

Diffusivity and the Mechanism of Mass Transport: Definition of concentrations, velocities and mass/molar fluxes, interrelationship between fluxes. Fick's law of diffusion, kinetic theory of diffusion in gases at low density, theory of ordinary diffusion in liquids. Prediction of diffusivity of gases, effect of temperature, pressure and composition on diffusivity, analogies between heat, mass and momentum transfer.

Module 5 (8hrs)

Shell mass balance - boundary conditions - diffusion through stagnant gas - diffusion with heterogeneous and homogeneous chemical reaction - diffusion and chemical reaction in porous catalyst – other similar diffusion problems, equation of continuity for binary mixtures in rectangular coordinates.

Note: For the University examinations, students are permitted to take tables of equations of continuity, motion, components of shear tensor and energy inside the examination hall.

Text Books

- Bird R.B., Stewart W.C and Lightfoot F.N, Transport phenomena, John Wiley & Sons..

Reference Books

1. Theodore L, Transport Phenomena for Engineers by, International text book Company, U.S.A
2. Geankoplis, Transport processes and unit operations, 3rd, , PHI, 1997.
3. Welty, Wicks and Wilson, Fundamentals of Heat, Momentum and Mass Transfer, John Wiley.
4. John C Slattery, Momentum, Energy and Mass transfer in continua, McGraw Hill, Co.
5. Robert S. Brodkey and Harry C Hersing, Transport Phenomena a Unified approach, McGraw Hill Book Co.
6. Bennet C U and Myers J E, Momentum, Heat and Mass Transfer, Tata McGraw Hill Publishing Co.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Module 1 (7 Hrs.)**	
1.1	Newton's law of viscosity, pressure and temperature dependence of viscosity of gases and liquids	2
1.2	prediction of viscosity of gases and numerical problems	2
1.3	Energy Transport	3
2	**Module 2 (12 Hrs.)**	
2.1	Application of shell balance to simple flow systems	6
2.2	derivation of continuity equation and equation of motion in rectangular coordinates	2
2.3	application of transport equations to steady flow problems	4
3	**Module 3 (11 Hrs.)**	
3.1	application of shell balance to heat conduction problems	6
3.2	application of equation of energy to steady-state heat transfer problems	5
4	**Module 4 (7 Hrs.)**	
4.1	Diffusivity and the mechanism of mass transport	1
4.2	Definition of concentrations, velocities and mass/molar fluxes, interrelationship between fluxes	2
4.3	kinetic theory of diffusion in gases at low density and theory of ordinary diffusion in liquids	4
5	**Module 5 (8 Hrs.)**	
5.1	Shell mass balance	6
5.2	equation of continuity for binary mixtures in rectangular coordinates	2

CHT 306	CHEMICAL TECHNOLOGY	CATEGORY	L	T	P	CREDIT
		PCC	3	1	0	4

Preamble: The subject reveals the study of producing pharmaceuticals, chemicals, and petroleum products in laboratories and processing plants. It helps the student to develop new chemical products and processes, test processing equipment and instrumentation, gather data, and monitor quality. Also the study of chemical technology will enable the students to do research, design, and construct safe, sustainable machinery to produce a wide range of valuable items.

Prerequisite: Basic knowledge in unit processes and unit operations.

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

CO 1	Sketch and explain the process flow diagram for the manufacture of inorganic chemicals.
CO 2	Explain and draw the process flow diagram of various processes for the production Chlor-alkali and fertiliser industries.
CO 3	Draw and explain the process flow diagram for production of carbon chemicals, surface coatings and cement.
CO 4	Sketch and explain the process flow diagram for the manufacture of glass, pesticides and natural products like soap, pulp and paper etc.
CO 5	Explain the food processing, production of alcohol and pharmaceutics
CO 6	Explain various process engineering technologies and process flow sheeting methods and select the best process for a product among the alternative methods available in the process industry.

Mapping of course outcomes with program outcomes

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

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	10
Understand	20	20	20
Apply	20	20	70
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

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

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

Course Level Assessment Questions

Course Outcome 1 (CO1): Sketch and explain the process flow diagram for the manufacture of inorganic chemicals.

1. List out the uses of dry CO2.
2. Discuss Linde's process for manufacture of O_2 and N_2. Discuss in brief the uses and properties of nitrogen and oxygen gases.
3. With a process flow diagram, describe the manufacture of sulfuric acid by DCDA process

Course Outcome 2 (CO2): Explain and draw the process flow diagram of various processes for the production Chlor-alkali and fertiliser industries.

1. Write short notes on compound fertilizers
2. Write down application of Soda ash and Caustic soda
3. Enlist various processes used for manufacturing of Caustic Soda. Explain in detail the mercury cell process for the production of Caustic Soda.

Course Outcome 3(CO3): Draw and explain the process flow diagram for production of carbon chemicals, surface coatings and cement.

1. Discuss Settling & Hardening of Cement in brief
2. State factors effecting setting time of cement.
3. With a neat flow chart, discuss the production of carbon black.

Course Outcome 4 (CO4): Sketch and explain the process flow diagram for the manufacture of glass, pesticides and natural products like soap, pulp and paper etc.

1. Briefly discuss Kraft (sulfate) process of pulping and compare with sulfite process.
2. Stating the classification of commercial glasses, explain the manufacture of flat glass.
3. List out 4 major pesticides used in india and their effects in human being.

Course Outcome 5 (CO5): Explain the food processing, production of alcohol and pharmaceutics

1. Explain various food processing methods in detail.
2. With a neat flow diagram, explain the production of industrial alcohol.
3. List the names of pharmaceutical industry in india.

Course Outcome 6 (CO6): Explain various process engineering technologies and process flow sheeting methods and select the best process for a product among the alternative methods available in the process industry.

1. Compare wet process and electric process in phosphoric acid manufacture.
2. Select suitable method for the production of pulp. List the advantages of the process over other processes.
3. Enlist various processes used for manufacturing of Caustic Soda. Explain in detail the mercury cell process for the production of Caustic Soda and its advantages over other processes.

Model Question Paper

QP CODE: **PAGES: 3**

Reg No: ______________ **Name: ______________**

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SIXTH SEMESTER B. TECH DEGREE EXAMINATION,MONTH & YEAR

Course Code: CHT 306

Max. Marks: 100 Duration: 3 Hours

Course Name: CHEMICAL TECHNOLOGY

PART A

Answer All questions. Each question carries 3 marks.

1. Discuss Settling & Hardening of Cement in brief.
2. Enlist the types of glass and explain any two in brief
3. Discuss in brief: NPK fertilizer.
4. Write down application of Soda ash and Caustic soda
5. List three methods of pulp production
6. State the sources and uses of hydrogen.
7. Discuss the major engineering problems associated with the production of sulphuric acid
8. List the uses of activated carbon.
9. List the food processing methods.
10. List the various steps in the production of absolute alcohol.

(3x10=30 marks)

PART B

Module 1

11.a. With a neat process flow diagram, describe the manufacture of sulfuric acid by DCDA process. (6 marks)

11.b. Discuss Linde's process for manufacture of O2 and N2. Discuss in brief the uses and properties of nitrogen and oxygen gases. (8 marks.)

OR

12. Enlist the methods for the commercial production of Carbon Dioxide. Briefly explain with a neat diagram, the manufacture of carbon dioxide using any method listed.(14marks.)

Module 2

13. Write a short note on Solvay process for the production of Soda ash.List out the major engineering problems associated with it. (14 marks)

OR

14. Explain the manufacturing process of Urea with flow diagram. List the advantages and disadvantages of the process described. (14 marks)

Module 3

15.a. Explain Furnace process for manufacturing of Carbon black with neat flow sheet.

(9 marks)

15.b. Describe in brief about graphite & carbon (5 marks.)

OR

16.a. Explain various types and constituents of Portland cement. (5 marks)

16.b. Explain the manufacturing process of Portland cement with a neat flow diagram.

(9marks)

Module 4

17. a.Explain manufacturing of paper with neat flow sheet. (7marks)

17.b. Explain manufacturing of pulp by using Kraft process. Discuss recovery of chemicals from black liquor. (7 marks)

OR

18.a. What are the different types of glasses and their uses? (5 marks)

18.b. Explain the manufacture of glycerine with a neat diagram, list out the major engineering problems for the production of glycerine. (9 marks)

Module 5

19. Explain any two processes for the manufacture of leather with a neat diagram. (14 marks)

OR

20.a. Explain the manufacturing process for the manufacture of industrial alcohol by fermentation with a neat diagram (7 marks)

20.b. Explain the process for the manufacture of absolute alcohol with a neat diagram

(7marks)

Syllabus

Module 1 (10hrs)

Fuel gases: natural gas, coke oven gas, producer gas, water gas, LPG. Industrial gases: carbon dioxide, hydrogen, nitrogen, oxygen. Sulphur and sulphuric acid: manufacturing of sulphur and sulphuric acid. phosphorus and phosophoric acid: wet process phosphoric acid- electric furnace phosphorus and phosphoric acid, single super phosphate and triple super phosphate.

Module 2 (9hrs.)

Chlor-alkali industries: salt, soda ash, baking soda, caustic soda, chlorine, hydrochloric acid. Nitrogen industries: ammonia, nitric acid, urea, fertilizer industries, ammonium sulphate, ammonium nitrate, nitrolime, MAP, DAP and nitrophosphates, mixed and complex fertilizers.

Module 3 (10hrs.)

Carbon chemicals, carbon black, activated carbon, synthetic graphite, calcium carbide. Surface coating industries: pigments, paints, varnishes, lacquers, industrial coatings. Cement: portland cement, constituents, types, raw materials and manufacturing processes.

Module 4 (8hrs)

Glass: classes of glass, raw materials, methods of manufacture. Ceramics and refractories (general study). Pesticides: DDT, Nicotine, Parathrins, Heptachlor, Endosulfan. Natural products industries: soaps and detergents, glycerine, pulp and paper, wood chemicals, Coal chemicals.

Module 5(8hrs)

General study of food processing, food byprodLts, leather, gelatin, adhesives, vegetable oils, animal fats and oils, waxes, sugar, starches and related products, industrial alcohol by fermentation, absolute alcohol, beers, wines and liquors. Pharmaceuticals, biotechnology.

Text Books

1. Austin G.T. (Ed.), Shreve's Chemical Process Industries, McGraw Hill

2. Gopal Rao M. & Sittig M. (Eds.), Dryden's Outlines of Chemical Technology, Affiliated East West Press .

3. Shukla S. D. and G. N. Pandey, "A Text Book of Chemical Technology. Vikas Publishing House, 1986.

Reference Books

1. Chemtech Vol. I – IV, Chemical Engineering Education Development Centre, Indian Institute of Technology, Madras, 1979.

2. Kirk-Othmer Encyclopaedia of Chemical Technology, John Wiley and Sons
3. Ullmann's Encyclopaedia of Industrial Chemistry, John Wiley and Sons

Course Contents and Lecture Schedule

No	Topic	No. of Lectures (Hrs.)
1	**MODULE 1 (10hrs)**	
1.1	Fuel gases: natural gas, coke oven gas, producer gas, water gas, LPG.	2
1.2	Industrial gases: carbon dioxide, hydrogen, nitrogen, oxygen	2
1.3	Sulphur and sulphuric acid: manufacturing of sulphur and sulphuric acid.	2
1.4	Phosphorus and phosophoric acid: wet process phosphoric acid-electric furnace phosphorus and phosphoric acid	2
1.5	Single super phosphate and triple super phosphate.	2
2	**MODULE 2 (9hrs)**	
2.1	Chlor-alkali industries: salt, soda ash, baking soda, caustic soda.	2
2.2	Manufacture of chlorine, hydrochloric acid. Nitrogen industries: ammonia, nitric acid, urea	2
2.3	Fertilizer industries, ammonium sulphate, ammonium nitrate	2
2.4	Nitrolime, MAP, DAP and nitrophosphates.	2
2.5	Mixed and complex fertilizers.	1
3	**MODULE 3(10hrs)**	
3.1	Carbon chemicals, carbon black, activated carbon.	2
3.2	Synthetic graphite, calcium carbide. Surface coating industries: pigments, paints,	2
3.3	Varnishes, lacquers, industrial coatings.	2
3.4	Cement: portland cement constituents, types.	2
3.5	Raw materials and manufacturing processes of Portland cement.	2
4	MODULE 4 (8hrs)	
4.1	Glass: classes of glass, raw materials, methods of manufacture.	1
4.2	Ceramics and refractories (general study). Pesticides: DDT, Nicotine	2
4.3	Parathrins, Heptachlor, Endosulfan	1
4.4	Natural products industries: soaps and detergents, glycerine	2
4.4	Pulp and paper, wood chemicals, Coal chemicals.	2
5	**MODULE 5 (8hrs)**	
5.1	General study of food processing, food byproduts,	1
5.2	Manufacture of leather, gelatin, adhesives.	1
5.3	vegetable oils, animal fats and oils, waxes,	2

5.4	sugar, starches and related products,	1
5.5	industrial alcohol by fermentation, absolute alcohol, beers, wines and liquors.	2
5.6	Pharmaceuticals, biotechnology.	1

CHT308	COMPREHENSIVE COURSE WORK	CATEGORY	L	T	P	CREDIT	YEAR OF INTRODUCTION
		PCC	1	0	0	1	2019

Preamble: The course is designed to ensure that the student have firmly grasped the foundational knowledge in Chemical Engineering. It provides an opportunity for the students to demonstrate their knowledge in various Chemical Engineering subjects.

Pre-requisite: Nil

Course outcomes: After the course, the student will able to:

CO1	Learn to prepare for a competitive examination
CO2	Comprehend the questions in Chemical Engineering field and answer them with confidence.
CO3	Communicate effectively with faculty in scholarly environments
CO4	Analyze the comprehensive knowledge gained in basic courses in the field of Chemical Engineering

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

Assessment pattern

Bloom's Category	**End Semester Examination (Marks)**
Remember	25
Understand	15
Apply	5
Analyze	5
Evaluate	
Create	

End Semester Examination Pattern:

A written examination will be conducted by the University at the end of the sixth semester. The written examination will be of objective type similar to the GATE examination. Syllabus for the comprehensive examination is based on following five Chemical Engineering core courses.

CHT 202 - Chemical Engineering Thermodynamics

CHT 204 –Heat Transfer Operations

CHT 205 - Fluid and Particle Mechanics

CHT 301–Mass Transfer Operations - I

CHT 305–Chemical Reaction Engineering

The written test will be of 50 marks with 50 multiple choice questions (10 questions from each module) with 4 choices of 1 mark each covering all the five core courses. There will be no negative marking. The pass minimum for this course is 25. The course should be mapped with a faculty and classes shall be arranged for practicing questions based on the core courses listed above.

Written examination	:	50marks
Total	**:**	**50 marks**

Course Level Assessment and Sample Questions

1) A principal plane is one where the shear stress will be:
A) Maximum
B) Minimum
C) Zero
D) Coverage of principal stress

2) In a differential manometer, the flowing fluid is water and the gauge fluid is mercury. If the manometer reading is 100mm, the differential head in meters is:
A) 13.6
B) 1.36
C)1.47
D)1.26

3) A rectangular open channel carries a flow of $2m^3$/sec/m, what is the value of minimum specific energy?

A) 0.74m

B) 1.11m

C) 1.48m

D) 1.85m

4) A pipe has diameter 0.4m, length 0.1km and coefficient of friction 0.005. What is the length of an equivalent pipe which has diameter 0.2m and coefficient of friction 0.008?

A) 195 m

B) 19.5 m

C)1.95 m

D) 1950 m

5) Which of the following statements are CORRECT?

P. For a rheopectic fluid, the apparent viscosity increases with time under a constant applied shear stress

Q. For a pseudoplastic fluid, the apparent viscosity decreases with time under a constant appliedshear stress

R. For a Bingham plastic, the apparent viscosity increases exponentially with the deformation rate

S. For a dilatant fluid, the apparent viscosity increases with increasing deformation rate

(A) P and Q only

(B) Q and R only

(C) R and S only

(A) P and S only

6) An irreversible gas phase reaction A → 5B is conducted in an isothermal batch reactor at constant pressure in the presence of an inert. The feed contains no B. If the volume of the gas at complete conversion must not exceed three times the initial volume, the minimum mol% of the inert in the feed must be …….

(A) 0

(B) 20

(C) 33

(D) 50

7) The reaction A → B is conducted in a isothermal batch reactor. If the conversion of A increases linearly with holding time, then the order of the reaction is

(A) 0

(B) 1

(C) 1.5
(D) 2

8) Threshold energy in a reaction is equal to the
(A) Activation energy
(B) Normal energy of the reactants
(C) Sum of A & B
(D) Difference between A & B

9) Calculate the loss of heat by radiation from a steel tube of diameter 70 mm and 3 m long at a temperature of 500 K, if the tube is located in a square brick conduit 0.3 m side at 300 K. Emissivity of steel= 0.79, emissivity of brick = 0.93.
(A) 2000 W
(B) 1588 W
(C) 2200 W
(D) 1800 W

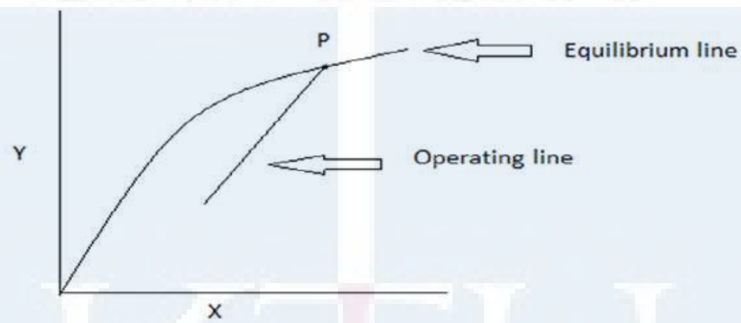
10) In a heat exchanger with steam outside the tubes, a liquid gets heated to 45 ^oC, when its flow velocity in the tubes is 2 m/s. If the flow velocity is reduced to 1 m/s, other things remaining the same, the temperature of the exit liquid will be
(A) less than 45 ^oC
(B) equal to 45 ^oC
(C) greater than 45 ^oC
(D) initially decreases and remains constant thereafter

11) In a shell and tube heat exchanger, baffles are provided on the shell side to
(A) prevent the stagnation of shell side fluid
(B) improve heat transfer
(C) provide support for tubes
(D) all of these

12) A counterflow shell and tube heat exchanger is used to heat water with hot exhaust gases. The water (Cp=4180 J/Kg.^oC) flows at a rate of 2 kg/s while the exhaust gases (Cp=1030 J/Kg ^oC) flows at a rate of 5.2 kg/s. If the heat transfer surface area is 32.5 m^2 and the overall heat transfer coefficient is 200 $W/m^{2o}C$, what is the NTU for the heat exchanger.
(A) 1.8
(B) 2.4
(C) 4.5
(D) 8.6

13) Prandtl number is the ratio of
(A) Mass diffusivity to thermal diffusivity
(B) Momentum diffusivity to thermal diffusivity
(C) Thermal diffusivity to mass diffusivity
(D) Thermal diffusivity to momentum diffusivity

14) The equilibrium and operating line of a vapour liquid separation process is given below with vapour composition Y on the ordinate and liquid composition X on the abscissa. The driving force at the point P in the diagram is ....



(A) One
(B) Greater than one
(C) Zero
(D) Infinity

15) For very large cooling duties, the cooling preferred is
(A) Induced draft cooling tower
(B) Natural draft cooling tower
(C)Forced draft cooling tower
(D)Atmospheric towers

****

Course Code: CHT 308

Comprehensive Course Work

MODULE 1(Fluid and Particle Mechanics)

Newton's law of viscosity-Physical properties of fluid-Variation of viscosity and density with temperature and pressure-Rheological Classification of fluids-Barometric Equation-Continuous gravity decanter and centrifugal decanter-Principles of Manometer- Simple manometer, inclined tube manometer. Reynold's number – Turbulence-Reynold's stress-Flow in boundary layers-Boundary layer separation and wake formation-Correction for fluid friction, Pump work-Compressible flow-Friction factor and Reynolds number relationship in laminar flow and turbulent flow-Effect of fittings and valves-Hydraulic radius and Equivalent diameter – Fluidization-Fluidized bed and Packed bed-Pressure drop- minimum fluidizing velocity-effect of pressure and temperature on fluidized bed behaviour-Pumps, fan, blower, compressor and its classification-Types of pumps-Centrifugal Pumps-Various losses – NPSH – Cavitation-Specific Speed-Priming.

MODULE 2(Chemical Engineering Thermodynamics)

Steady and unsteady state mass and energy balances including multiphase, multicomponent, reacting and non-reacting systems. Use of tie components; recycle, bypass and purge calculations; Gibb's phase rule and degree of freedom analysis. First and Second laws of thermodynamics. Applications of first law to close and open systems. Second law and Entropy. Thermodynamic properties of pure substances: Equation of State and residual properties, properties of mixtures: partial molar properties, fugacity, excess properties and activity coefficients; phase equilibria: predicting VLE of systems; chemical reaction equilibrium.

MODULE 3 (Heat Transfer Operations)

Conduction heat transfer- Fourier heat conduction equation, conduction through plane, cylindrical and spherical wall, conduction through composite slab - multi-layered plane, cylindrical and spherical shells, lumped capacity analysis, Forced Convection - General methods for estimation of forced convection heat transfer coefficient for flow through tubes and flow over flat plates, Natural Convection-natural convection from vertical and horizontal surfaces under laminar and turbulent conditions for plates and cylinders under constant heat flux and wall temperature conditions, Heat transfer by radiation-radiation between large parallel gray planes, concentric cylinders and spheres, radiation between a small gray body and a large gray enclosure, Heat exchangers - Concept of overall heat transfer coefficient-determination of overall heat transfer coefficient with and without fouling, concept of logarithmic mean temperature difference and its correction factor, NTU method, determination of area, length,number of tubes required for a given duty in different configurations using LMTD and NTU method of analysis.

Evaporation- capacity and economy of evaporators, material and energy balances for single effect evaporator and the calculations on single effect evaporator.

MODULE 4 (Mass Transfer Operations – I)

Molecular diffusion-mass fluxes J_A and N_A - Fick's law, steady state diffusion of A through stagnant B and equimolar counter diffusion, Mass transfer coefficients, dimensionless groups, theories of mass transfer, interphase mass transfer, Gas-Liquid contacting equipments for mass transfer operations, factors affecting column performance, Gas absorption, Material balance in counter current and concurrent absorption, multistage operation, number of plates, tray efficiency, design of packed columns, transfer units, adsorption, adsorption isotherms, rate of adsorption, humidification, Lewis relation, types of cooling towers, drying, moisture content, rate of drying, batch and continuous drying.

MODULE 5 (Chemical Reaction Engineering)

Theories of reaction rates, kinetics of homogeneous reaction, interpretation of kinetic data, reactions in ideal reactors, single and multiple reactions, non-isothermal reactors, Heat effects: adiabatic and non -adiabatic operations, Non-ideal reactors, residence time distribution, RTD in ideal reactors, single parameter model reactions.

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CHL 332	MASS TRANSFER OPERATIONS LAB	CATEGORY	L	T	P	CREDIT
		PCC	0	0	3	2

Preamble: This course familiarizes the student with various mass transfer operations by doing experiments. This course helps the students to operate and understand the working of mass transfer equipments.

Prerequisite: Theoretical knowledge on Mass Transfer Operations.

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

CO 1	Apply the fundamental knowledge of mass transfer in related practical problems
CO 2	Analyse different mass transfer operations
CO 3	Experiment with various mass transfer equipments
CO 4	Examine separation processes such as simple distillation, steam distillation etc. to estimate the composition in products
CO 5	Plan and conduct the experiments and present the experimental data meaningfully
CO 6	Develop teamwork skills

Mapping of course outcomes with program outcomes

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

Assessment Pattern

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	75	75	2.5 hours

Continuous Internal Evaluation Pattern:

Attendance : 15 marks
Continuous Assessment : 30 marks
Internal Test (Immediately before the second series test) : 30 marks

End Semester Examination Pattern: The following guidelines should be followed regarding award of marks

(a) Preliminary work	: 15 Marks
(b) Implementing the work/Conducting the experiment	: 10 Marks
(c) Performance, result and inference (usage of equipments and trouble shooting)	: 25 Marks
(d) Viva voce	: 20 marks
(e) Record	: 5 Marks

General instructions: Practical examination to be conducted immediately after the second series test covering entire syllabus given below. Evaluation is a serious process that is to be conducted under the equal responsibility of both the internal and external examiners. The number of candidates evaluated per day should not exceed 20. Students shall be allowed for the University examination only on submitting the duly certified record. The external examiner shall endorse the record.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Plot the percentage actual recovery against solvent to feed ratio for single stage leaching.
2. Draw the binodal solubility curve for benzene-water-acetic acid system.
3. Determine the Freundlich constants for adsorption of acetic acid on activated carbon.

Course Outcome 2 (CO2)

1. Find the actual and theoretical recovery for simple leaching with varying number of stages.
2. Draw tie line in binodal solubility curve of benzene-water- acetic acid system.
3. Verify the Rayleigh equation for the simple distillation experiment.

Course Outcome 3(CO3):

1. Find the stage efficiency for the cross current leaching experiment.
2. Find the mass transfer coeffient for wetted wall column experiment.
3. Determine the time of drying using the batch drying set up.

Course Outcome 4 (CO4):

1. Compare vaporisation and thermal efficiency for steam distillation of turpentine.
2. Verify material balance equation for simple distillation of methanol-water mixture.
3. Draw the binodal solubility curve for benzene-water-acetic acid system.

Course Outcome 5 (CO5):

1. Find the overall stage efficiency of continuous counter current leaching unit.
2. Compare the recovery between simple leaching with varying number of stages and varying solvent to feed ratio.

Course Outcome 6 (CO6):

1. Demonstrate the working of diffusivity measurement apparatus.
2. Explain the working of mass transfer coefficient in surface evaporation equipment.
3. Demonstrate the working of atmospheric batch drying unit.

LIST OF EXPERIMENTS (A minimum of 8 experiments has to be conducted)

1. Diffusion coefficient measurement
2. Simple Distillation
3. Steam Distillation
4. Surface Evaporation-free convection mass transfer
5. Liquid extraction- Determination of Ternary liquid-liquid equilibria
6. Simple leaching-varying solvent to feed ratio
7. Simple leaching- varying number of stages
8. Cross current leaching
9. Counter current leaching
10. Adsorption Isotherm
11. Atmospheric batch drying
12. Wetted wall column-measurement of mass transfer coefficient
13. Any other experiments related to mass transfer operations applicable in Chemical Engineering.

Reference Books

1. Robert E Treybal, Mass Transfer Operations, McGraw Hill.
2. K V Narayanan and B Lakshmikutty, Mass Transfer: Theory and Applications, CBS Publishers and Distributors Pvt. Ltd.

CHL 334	CHEMICAL REACTION ENGINEERING LAB	CATEGORY	L	T	P	CREDIT
		PCC	0	0	3	2

Preamble: This course help the students to understand the principles of kinetics of Chemical Reactions through experimentation. This practical course familiarizes the students the principle and working of various chemical reactors.

Prerequisite: Theoretical knowledge of Chemical Reaction Engineering.

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

CO 1	Deduce kinetic equation of homogenous chemical reactions and analyse the factors effecting the reactions
CO 2	Analyse the effect of temperature in chemical equation and validation of Arrhenius law.
CO 3	Determine the kinetics of reaction in ideal reactors- Batch Reactor, PFR and MFR
CO 4	Analyse the principle, working, selection of Chemical Reactors and arriving at designing ideal reactors.
CO 5	Account for non ideality in chemical reactors by calculating residence time distribution
CO 6	Interpret and present the experimental data meaningfully and develop teamwork skills.

Mapping of course outcomes with program outcomes

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

Assessment Pattern

Mark distribution

Total Marks	**CIE**	**ESE**	**ESE Duration**
150	75	75	2.5 hours

Continuous Internal Evaluation Pattern:

Attendance	:	15 marks
Continuous Assessment	:	30 marks
Internal Test (Immediately before the second series test)	:	30 marks

End Semester Examination Pattern: The following guidelines should be followed regarding award of marks

(a) Preliminary work	: 15Marks
(b) Implementing the work/Conducting the experiment	: 10 Marks
(c) Performance, result and inference (usage of equipments and trouble shooting)	: 25 Marks
(d) Viva voce	: 20 marks
(e) Record	: 5 Marks

General instructions: Practical examination to be conducted immediately after the second series test covering entire syllabus given below. Evaluation is a serious process that is to be conducted under the equal responsibility of both the internal and external examiners. The number of candidates evaluated per day should not exceed 20. Students shall be allowed for the University examination only on submitting the duly certified record. The external examiner shall endorse the record.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Discuss the effect of catalyst on activation energy.
2. What is Arrhenius theory for temperature dependency of reaction rate

Course Outcome 2 (CO2)

1. Explain integral and differential methods for rate analysis
2. Define equivalent weight. what is its relation to valency and atomic weight.

Course Outcome 3(CO3):

1. Compare the performance of MFRs for first and second order reactions.
2. What are essential characteristics of a PFR

Course Outcome 4 (CO4):

1. Explain how the conversion in a reactor can be obtained from RTD studies
2. What are the reasons behind non-ideal behaviour of reactors

Course Outcome 5 (CO5):

1. Explain the effect of recycle ratio in a autocatalytic reaction.
2. What is the effect of multiple PFRs in series.

Course Outcome 6 (CO6):

1. How do we calculate the optimum recycle ratio a recycle reactor? What is its significance?
2. Write the advantages and disadvantages of conducting a laboratory kinetic study in a batch reactor over other reactor configurations

LIST OF EXPERIMENTS (Minimum of 8 experiments are mandatory)

1. Isothermal Batch Reactor
2. Isothermal Plug Flow Reactor
3. Isothermal CSTR
4. Packed Bed Reactor
5. RTD Studies in a Packed Bed Reactor
6. RTD Studies in CSTR
7. RTD Studies in PFR
8. Combined Flow Reactor
9. UV Photo Reactor
10. Determination of activation energy
11. Kinetics of reactions
12. Recycle Reactor
13. Electrochemical Reactor
14. Any other experiments related to chemical reaction engineering applicable in chemical engineering field.

Reference Books

1. H, Scott Fogler, "Elements of Chemical Reaction Engineering", Prentice Hall of India.
2. K.G Denbigh& J.C.R Turner, „Chemical Reactor Theory- An Introduction‟, 3rd Ed., Cambridge University Press
3. Levenspiel Octave , "Chemical Reaction Engineering", John Wiley & Son‟s.
4. Ronald W. Missen, Charles A. Mims, Bradley A. Saville, „Introduction to Chemical Reaction Engineering and Kinetics‟, John Wiley & Sons
5. Smith J.M, "Chemical Engineering Kinetics," McGraw Hill.

SEMESTER VI

PROGRAM ELECTIVE I

CHT 312	BIOCHEMICAL ENGINEERING	CATEGORY	L	T	P	CREDIT
		PEC	2	1	0	3

Preamble: Biochemical engineering, also known as bioprocess engineering amalgamates the facts from both chemical engineering and biological engineering. It mainly deals with the design, construction, and advancement of unit processes that involve biological organisms or organic molecules. This subject has various applications in the areas of biofuels, pharmaceuticals, agriculture, food sciences, biotechnology and water treatment processes.

This course would enable students to gain a basic knowledge on application of the biological processes to make useful chemicals which can be utilized in the aforesaid areas.

Prerequisite: Nil

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

CO1	Describe different types of cells, classification of kingdom Protista and potential of chemicals of life
CO2	Interpret kinetics of enzyme catalyzed reactions
CO3	Describe Immobilized enzyme technology. Apply basic knowledge of energy and material balances for understanding the metabolic pathways within the cell
CO4	Apply heat and mass transfer principles in bioreactors and bioprocess
CO5	Describe design and operation of a fermentation process and use of sensors

Mapping of course outcomes with program outcomes

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

Assessment Pattern

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination**
	1	**2**	
Remember	10	10	10
Understand	20	20	30
Apply	20	20	60
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

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

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

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Compare eukaryotic and prokaryotic cells in terms of internal structure and functions
2. With the help of chemical structure, comment on the functional importance of cellulose, phospholipids, and amino acids

Course Outcome 2 (CO2)

1) The following initial rate data were obtained as a function of initial substrate concentration. Evaluate the Michaelis- Menten kinetic parameters by employing the Eadie-Hofstee plot.

Substrate Concentration (mol/L).	Initial reaction rate (mol/L s)
0.0031	0.11
0.005	0.15
0.0063	0.14
0.009	0.17
0.01	0.21

2) Explain competitive and uncompetitive inhibitions in enzymatic reactions with suitable plots

Course Outcome 3(CO3):

1. Give different methods of immobilization of enzymes
2. Compare the number of ATP molecules produced during glycolysis in TCA cycle and electron transport chain.

Course Outcome 4 (CO4):

1. Explain the oxygen transfer in fermentation process with the help of mass transfer coefficient

2. Describe the working of airlift and fluidized bed bioreactors

Course Outcome 5 (CO5):

1. Explain the medium formulation in a fermentation process

2. Describe on line sensors with suitable example

Model Question paper

QP CODE: **PAGES:2**

Reg No:______________

Name :______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
SIXTH SEMESTER B.TECH DEGREE EXAMINATION,
MONTH & YEAR
Course Code: CHT 312 BIOCHEMICAL ENGINEERING

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

(2019-Scheme)

PART A

(Answer all questions, each question carries 3 marks)

1. Write about the sugar which is used in genetic material
2. Write examples of primary metabolites and secondary metabolites?
3. Explain Eadie Hofstee plot
4. Explain the substrate activation.
5. List out six enzymes of industrial importance?
6. What are the role of ATP and ADP in metabolic reactions
7. What is Damkohler number?
8. Explain three operational stages in a bioprocess
9. Explain the working of an electrostatic precipitator.
10. What are the sources and effects of noise pollution?

PART B

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

MODULE-I

11. a) Draw a neat sketch of a prokaryotic cell and explain its structure (5)

    b) Explain the functions of different eukaryotic cell organelles (9)

12. a) Explain differential centrifugation method of cell fractionation (9)

    b) Describe five different classification of lipids . (5)

MODULE-II

13. a) Explain reversible modulation in the biosynthesis of L- isoleucine (5)

    b) Derive Michaelis Menton Equation for single substrate system (9)

14. a) Derive the kinetic expression for a non-competitive inhibition (7)

    b) Describe enzyme specificity hypothesis (7)

MODULE-III

15. a) Explain in the physical methods of enzyme immobilization (7)

    b) Describe the pentose phosphate cycle with a neat diagram (7)

16. a) With a neat figure, explain the growth cycle in a microbial batch cultivation (7)

    b) Explain passive and active transport in cell membranes (7)

MODULE-IV

17. a) Describe with a diagram the continuous heat sterilization (7)

    b) Describe the rate of metabolic oxygen utilization in a fermentation process (7)

18. a) Explain in the working of a Photobioreactors (6)

    (b) List out the steps involved in the transfer of oxygen from a gas bubble to reaction site inside a cell (8)

MODULE-V

19. a) What are the advantages and disadvantages of offline sensors? (7)

    b) What are the characteristics of gas analysis sensors? (7)

20. Describe the design and operation of a typical aseptic, aerobic fermentation process (14)

Syllabus

Module 1 (6 Hours)

Micro Biology, Cell theory, Structure of cells, Cell fractionation, protist kingdom and their distinguishing characteristics . Chemicals of life: repetitive and non repetitive bio polymers - lipids, sugars and polysaccharides, amino acids and proteins. Protein structure nucleotides RNA and DNA

Module 2 (7 Hours)

Kinetics of Enzyme catalyzed reactions: simple enzyme kinetics with one or two substrates, Michaelis - Menten Kinetics, Evaluation of parameters in Michaelis – Menten equation, Substrate concentration dependence of enzyme catalysed reactions: substrate activation and inhibition, Modulation and regulation of enzyme activity – competitive and uncompetitive inhibition. Enzyme specificity and enzyme specificity hypotheses

Module 3 (7 Hours)

Enzymes of industrial importance. Immobilized enzyme technology: enzyme immobilization, medical and analytical applications of immobilized enzymes. Batch cultivation - growth cycle (lag, exponential, stationary and death phase)
Metabolic pathways and energetics of the cell: Metabolic reaction coupling : ATP, ADP and NAD. Oxidation and reduction- Coupling via NAD. Embden-Meyerhof pathway (EMP), Pentose phosphate cycle , Respiration - TCA cycle. Transport across cell membranes - passive transport, active transport and facilitated diffusion.

Module 4 (7 Hours)

Transport phenomena in Bio process system-Gas-liquid mass transfer in cellular system - basic mass transfer and concepts - rates of metabolic oxygen utilization – determination of oxygen transfer rates-mass transfer across free falling or raising bubble and free surface with or without agitation in heat transfer. Biochemical reactors-specifications Continuous stirred tank bioreactor, bubble column bioreactor, Airlift bioreactors, Fluidized bed bioreactors, Packed bed bioreactors, and photo bioreactors. Types of reactors for sterilization

Module 5 (8 Hours)

Fermentation technology, medium formulation, design and operation of a typical aseptic, aerobic fermentation process. Different configurations for fermentors. Concept of biosensors. Physical and chemical sensors, gas analysis sensors, On-line sensors and offline sensors.for cell properties

Text Books

1. James E. Bailey and David F. Ollis., "Bio-chemical Engineering Fundamentals". Mc Graw Hill International Editions.
2. D G Rao., "Introduction to Biochemical Engineering", Tata Mc Graw Hill.

3. Michael L Shuler and Frikret Khargi., "Bioprocess Engineering Basic Concepts" PHI Publications.

Reference Books

1. Biochemical Engineering by H. W.Blanch & D.S. Clark, Marcel Dekker, Inc., 1997.
2. Bioprocess Engineering principles Paulin M Doran ISBN-978-0-12-220851-5

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Module I (6 hours)**	
1.1	Structure of cells, prokaryotic and eukaryotic cells,	1
1.2	Cell fractionation	1
1.3	Protist kingdom and their distinguishing characteristics	1
1.4	Classification of microorganisms belonging to the kingdom of protists	1
1.5	Chemicals of life: repetitive and non repetitive bio polymers Lipids, Sugars and polysaccharides	1
1.6	Amino acids and proteins, Protein structure, Nucleotides RNA and DNA	1
2	**Module II (7 hours)**	
2.1	Enzyme substrate complex and enzyme action simple enzyme kinetics with one or two substrates	1
2.2	Derivation of Michaelis - Menten Kinetics, evaluation of parameters in M M kinetics	1
2.3	Description of Substrate activation and inhibition	1
2.4	Modulation and regulation of enzyme activity- mechanism of reversible enzyme modulation	1
2.5	Derivation of competitive inhibition	1
2.6	Derivation of uncompetitive inhibition	1
2.7	Different factors affecting enzyme activity, Enzyme specificity and enzyme specificity hypotheses	1
3	**Module III (7 hours)**	
3.1	Important enzymes of industrial importance, Different methods for Enzyme immobilization	1
3.2	Medical and analytical applications of immobilized enzymes	1
3.3	Growth cycle in batch cultivation -(lag, exponential, stationary and death phase)	1
3.4	Metabolic reaction coupling : ATP, ADP and NAD	1
3.5	Oxidation and reduction- Coupling via NAD	1
3.6	Embden-Meyerhof pathway (EMP), Pentose phosphate cycle, Respiration - TCA cycle	1
3.7	Transport across cell membranes - passive transport, active transport and facilitated diffusion.	1
4	**Module IV (7 hours)**	

4.1	Gas-liquid mass transfer in cellular system – basic mass transfer and concepts, rates of metabolic oxygen utilization	1
4.2	Determination of oxygen transfer rates-mass transfer across free falling or raising bubble and free surface with or without agitation in heat transfer	1
4.3	Specifications and operational stages in a bioreactor, Continuous stirred tank bioreactor, bubble column bioreactor	2
4.4	Airlift bioreactors, Fluidized bed bioreactors,	1
4.5	Packed bed bioreactors, and photo bioreactors	1
4.6	Types of reactors for batch sterilization, Types of reactors for continuous sterilization	1
5	**Module V (8 hours)**	
5.1	Medium formulation in fermentation	1
5.2	Design and operation of a typical aseptic, aerobic fermentation process.	2
5.3	Alternate bioreactor configurations	1
5.4	Sensors of the physical environment, gas analysis sensors	1
5.5	Medium chemical sensors	1
5.6	On-line sensors for cell properties	1
5.7	Off-line sensors for analytical methods	1

CHT322	ENERGY ENGINEERING	CATEGORY	L	T	P	CREDIT
		PEC	2	1	0	3

Preamble: After studying this course students will be aware of different form of energy and methods for harnessing different energy resources. They also understand the importance of energy conservation and the different methods employed for energy conservation in industry and day to day life.

Prerequisite: NIL

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

CO 1	Identify different sources of energy , analyse the energy scenario and understand different conventional energy production systems
CO 2	Explain the concepts of solar and ocean energy conversion
CO 3	Explain the Wind and biomass energy conversion technologies
CO 4	Explain the working and types of fuel cells and MHD systems
CO 5	Explain the concepts of energy conservation and energy audit and apply the knowledge in process plants and daily life

Mapping of course outcomes with program outcomes

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

Assessment Pattern

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

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

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

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

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Differentiate between renewable and non renewable energy resources
2. Analyse the energy situation in India and give your suggestions for a better energy independence
3. Classify the different energy resources

Course Outcome 2 (CO2)

1. Discuss different Solar energy conversion technologies
2. Analyse the working of Solar PV system and suggest the methods to improve the efficiency
3. Discuss the different ocean energy conversion technologies and comment on their future

Course Outcome 3(CO3):

1. Analyse the wind energy harnessing status in India
2. Discuss different wind energy conversion technologies
3. Analyse the process of biomass conversion technologies

Course Outcome 4 (CO4):

1. Explain the working of a fuel cell and discuss the classification
2. Explain the working of MHD systems

Course Outcome 5 (CO5):

1. discuss the energy conservation methods employed in chemical process plants
2. Analyse the concept of pinch Technology
3. Discuss the use of cogeneration as a energy conservation tool

Model Question paper

QP CODE: **PAGES:2**

Reg No:______________

Name :______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SIXTH SEMESTER B.TECH DEGREE EXAMINATION,

MONTH & YEAR

Course Code: CHT 322 ENERGY ENGINEERING

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

(2019-Scheme)

PART A

(Answer all questions, each question carries 3 marks)

1.Write a note on classification of energy resources
2.Explain the principle of fluidised bed combustion
3.Write the principle and working of solar pond
4.Discuss the principle of tidal energy conversion
5.Explain the steps in the anaerobic digestion of biomass
6.Discuss the wind energy situation in India
7.What is a fuel cell? Explain the principle and working
8.Explain the methods to harness geothermal energy
9.Distillation is an energy intensive operation. Give the energy conservation measures in a distillation column
10. Explain the concept of Pinch Technology (10x3=30 marks)

PART B

11. Discuss the present Indian energy scenario and give your suggestions for a better energy sustainability (14 marks)

OR

12. With a neat lay out explain the working of thermal power plant. List out the merits and demerits (14 marks)

OR

13. a) Explain the working of different solar collectors (7 marks)

b) Solar PV cells and its future. Comment (7 marks)

14. With a neat diagram explain the working of open and closed cycle ocean thermal energy conversion systems (14 marks)

OR

15. Explain different wind energy conversion systems (14 marks)

16. Thermo chemical routes of biomass energy conversion systems: Explain the principle and working (14 marks)

OR

17. Discuss the classification of fuel cell. Explain the working any two fuel cells (14 marks)

18. With a neat diagram explain the working MHD systems (14 marks)

19. What is energy audit? Discuss different types and objectives (14 marks)

OR

20. Write in detail about the energy conservation measures in a chemical process plants

(14 marks)

Syllabus

Module 1 (6 hours)

Energy, general classification of energy, world energy resources and energy consumption, Indian energy resources and energy consumption, energy Crisis, energy alternatives, thermal, hydel and nuclear power plants, efficiency, merits and demerits of the above power plants, fluidized bed combustion, combined cycle power plants

Module 2 (7 hours)

Solar energy, solar thermal systems, flat plate collectors, focusing collectors, solar water heating, solar cooling, solar distillation, solar refrigeration, solar dryers, solar pond, solar thermal power generation, solar energy application in India, , photo voltaic systems , energy plantations.

Ocean wave energy conversion, ocean thermal energy conversion, tidal energy conversion,

Module 3 (7 hours)

Wind energy, types of windmills, types of wind rotors, Darrieus rotor and Savanius rotor, wind electric power generation, wind power in India, economics of wind farm

Biomass energy resources, thermochemical and biochemical methods of biomass conversion, combustion, gasification, pyrolysis, fermentation, anaerobic digestion

Module 4 (7 hours)

Fuel cells, alkaline fuel cell, phosphoric acid fuel cell, molten carbonate fuel cell, solid oxide fuel cell, solid polymer electrolyte fuel cell, Basic concepts of Microbial Fuel Cell
Magneto hydro dynamics: open cycle and closed cycle systems,geothermal energy.

Module 5 (8 hours)

Energy audit and Energy conservation in chemical process plants, energy saving in heat exchangers, distillation columns, furnaces and boilers, steam economy in chemical plants, energy conservation in petroleum, fertilizer and steel industry, cogeneration (CHP), pinch technology, recycling for energy saving, electrical energy conservation in chemical Process plants, environmental aspects of energy use.

Text Books

1. Rao S. &Parulekar B.B., Energy Technology, Khanna Publishers.
2. Bansal N.K., Kleeman M. &Meliss M., Renewable Energy Sources & Conversion Tech., Tata McGraw Hill.
3. Goldmberg J., Johansson, Reddy A.K.N. & Williams R.H., Energy for a Sustainable World, John Wiley

Reference Books

1. Sukhatme S.P., Solar Energy, Tata McGraw Hill
2. Mittal K.M., Non-Conventional Energy Systems, Wheeler Publications
3. Venkataswarlu D.I, Chemical Technology, S. Chand
4. Pandey G.N., A Text Book on Energy System and Engineering, Vikas Publishing.
5. Rai G.D., Non-Conventional Energy Sources, Khanna Publishers.
6. S.S.Thipse, Energy conservation and management, Narosa Publishing House

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Energy classification, energy scenario and types of power plants (6 hours)**	
1.1	general classification of energy,	1
1.2	world energy resources and energy consumption, Indian energy resources and energy consumption	1
1.3	energy Crisis, energy alternatives,	1
1.4	thermal, hydel and nuclear power plants	1
1.5	efficiency , merits and demerits of the above power plants, fluidized bed combustion	1
1.6	combined cycle power plants	1

2	**Solar energy and ocean energy (7 hours)**	
2.1	solar thermal systems, flat plate collectors, focusing collectors	1
2.2	solar water heating, solar cooling, solar distillation	1
2.3	solar refrigeration, solar dryers, solar pond	1
2.4	solar thermal power generation, solar energy application in India	1
2.5	photo voltaic systems , energy plantations	1
2.6	Ocean wave energy conversion, ocean thermal energy conversion, ,	1
2.7	tidal energy conversion	1
3	**Wind Energy and Biomass Energy (7 hours)**	
3.1	Wind energy, types of windmills	1
3.2	Types of wind rotors, Darrieus rotor and Savanius rotor,	1
3.3	Wind electric power generation, wind power in India	1
3.4	, economics of wind farm	1
3.5	Biomass energy resources,	1
3.6	Thermo-chemical methods of biomass conversion, combustion, gasification, pyrolysis	1
3.7	Biochemical methods of biomass conversion: fermentation, anaerobic digestion	1
4	**Fuel cells, MHD and geothermal energy (7 hours)**	
4.1	Fuel cells, alkaline fuel cell,	1
4.2	Phosphoric acid fuel cell, Molten carbonate fuel cell	1
4.3	Solid oxide fuel cell, solid polymer electrolyte fuel cell, Basic concepts of Microbial Fuel Cell	1
4.4	Magneto hydro dynamics: introduction	1
4.5	Open cycle and closed cycle systems,	1
4.6	Geothermal energy	1
4.7	Methods for harnessing geothermal energy	1
5	**Energy audit and Energy conservation (8 hours)**	
5.1	Energy audit and Energy conservation in chemical process plants,	1
5.2	Energy saving in heat exchangers, distillation columns, furnaces and boilers	1
5.3	steam economy in chemical plants,	1
5.4	energy conservation in petroleum, fertilizer and steel industry,	1
5.5	cogeneration (CHP),	1
5.6	pinch technology	1
5.7	recycling for energy saving	1
5.8	Electrical energy conservation in chemical Process plants, environmental aspects of energy use.	1

CHT332	NUMERICAL METHODS FOR PROCESS ENGINEERS	CATEGORY	L	T	P	CREDIT
		PEC	2	1	0	3

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

Prerequisite:Nil

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

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

Mapping of course outcomes with program outcomes

	PO1	PO2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3										2
CO 2	3	3			3							2
CO 3	3	3										2
CO 4	3	3										2
CO 5	3	3										2
CO 6	3	3	3									2

Assessment Pattern

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination**
	1	**2**	
Remember	10	10	10
Understand	20	20	20
Apply	20	20	70
Analyse			
Evaluate			
Create			

Mark distribution

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

Continuous Internal Evaluation Pattern:

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

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

Course Level Assessment Questions

Course Outcome 1 (CO1): Identify the errors, source of error and its effect on any numerical computations**.**

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

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

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

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

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

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

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

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

- Apply Gauss – Jordan method to solve the following equations

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

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

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

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

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

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

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

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

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

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

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

At the initial time, t = 0, the salt concentration in the tank is 50 g/L. Determine the salt concentration after 3 minutes by Runge-Kutta 4th order method with a step size of, h = 0.75 min

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

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

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

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

Model Question Paper

QP CODE: **PAGES: 4**

Reg No.:________________ Name:______________________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SIXTH SEMESTER B. TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: CHT332

Course Name: NUMERICAL METHODS FOR PROCESS ENGINEERS

Max. Marks: 100 Duration: 3 Hours

PART A

Answer All the Questions (10 x 3 = 30) **Marks**

1 List the possible errors that may encounter in numerical calculations? 3

2 The specific volume of n-butane at 500 K and 18 atm using the Redlich–Kwong equation of state is given as $18v^3 - 41v^2 + 9.4v - 1 = 0$. Obtain the solution to find out the volume using Newton-Raphson method. 3

3 Using Jacobi's method to solve, $10x + y + z = 12,\ \ 2x + 10y + z = 13,\ \ x + y + 5z = 7$. 3

4 Find the numerically larger eigen value of the matrix A=$\begin{bmatrix} 3 & -5 \\ -2 & 4 \end{bmatrix}$ by Power method. 3

5 Derive Newton's forward interpolating polynomial. 3

6 Surface tension of water is measured at various temperatures. It decreases with temperature as follows: 3

T (^{0}C)	20	30	40	50

γ(mN m^{-1})	72.8	71.2	69.6	67.9

Estimate the surface tension at 37^0C using Lagrangian interpolation formula.

7 Obtain $\left[\frac{d^2y}{dx^2}\right]$ using Newton's backward difference formula. 3

8 Use Simpsons 1/3rd formula to numerically integrate $\int_0^2 e^{x^2}\,dx$. 3

9 Using simple Euler's method, $\frac{dy}{dx} = \frac{y-x}{y+x}$, *with* $y(0)=1$, *and find* $x = 0.1$. 3

10 Show that central difference approximation of derivatives have 2^{nd} order accuracy. 3

PART B

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

Module I

11 a) A spherical particle is falling through a liquid such that its true Reynolds number is 700. However, due to imprecise estimates of the physical properties, the value of Reynolds number is reported to be 664.8 only. The drag coefficient depends on Reynolds number as per the equation: $C_D = \left(\frac{12}{N_{Re}}\right)[1 + 0.15(N_{Re})^{0.687}]$ where C_D is the drag coefficient and N_{Re} is Reynolds number. Determine the percentage relative error in the value of the drag coefficient if the inaccurate value of Reynolds number is used. 8

b) Find the real root of the equation $3x - \sqrt{(1+\sin x)} = 0$, using bisection method in four steps. 6

12 a) Air at 25 oC and 1 atm flows through a 4mm diameter tube with an average velocity of 50 m/s. the roughness is ε=0.0015 mm. Calculate the friction factor using Newton's Raphson method

$$\frac{1}{\sqrt{f}} = -2\log\left(\frac{\varepsilon/D}{3.7} + \frac{2.51}{Re\sqrt{f}}\right)$$

Determine the pressure drop in a 1m section of the tube using the relation 8

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

Density of air at 25°C and 1 atm is 1.23 kg/m^3 and viscosity is 1.79x10^{-5} kg/ms

b) Find all the roots of the equation $x^3 - 6x^2 + 11x - 6 = 0$, by Graeff's root squaring method with four squaring. 6

Module II

13 a) Find the inverse of the coefficient matrix of the system by Gauss-Jordan method.

$$\begin{bmatrix}1 & 1 & 1\\ 4 & 3 & -1\\ 3 & 5 & 3\end{bmatrix}\begin{bmatrix}x1\\ x2\\ x3\end{bmatrix} = \begin{bmatrix}1\\ 6\\ 4\end{bmatrix}$$

6

b) Two separators are used in a process plant to treat a feed (F) containing 100 kg of a mixture of three chemicals A, B and C. In the first separator, 80 % of A is removed and, in the second separator, 83 % of B is removed. The final outlet 8 contains a C rich stream. The compositions of the streams shown in the figure are given below:

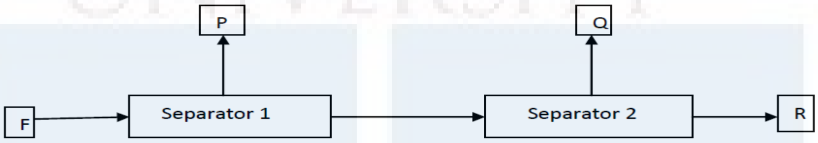
Stream F: $A = 50\%; B = 30\%; C = 20\%$

Stream P: $A = 80\%; B = 10\%; C = 10\%$

Stream Q: $A = 2\%; B = 83\%; C = 15\%$

Stream R: $A = 6\%; B = 12\%; C = 82\%$.

Determine the quantity of mixture in each of the streams P, Q and R using Gauss elimination method.



14 a) Using Gauss-Seidel method, find the solution of the following system of linear equations correct to three decimal places. 7

$$10x + y - 2z = 7.74$$
$$x + 12y + z = 39.66$$
$$3x + 4y + 15z = 54.8$$

b) Find the real root of the equations 7

$$x^2 - y^2 = 4$$
$$x^2 + y^2 = 16$$

Module III

15 a) Using Divided difference formula find the missing value from the table 7

x	1	2	4	5	6
y	14	15	5	......	9

b) Use Stirling's formula to evaluate y_{28} given that 7

$y_{20} = 49225, y_{25} = 48316,\ y_{30} = 47236,\ y_{35} = 45926,\ y_{40} = 44306.$

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

b) Use Newton's divided difference formula to find f(x) from the following data. 7

x	0	2	3	4	6	7
f(x)	0	8	0	-72	0	1008

Module IV

17 a) Given that 7

x	1.0	1.1	1.2	1.3	1.4	1.5	1.6
y	7.989	8.403	8.781	9.129	9.451	9.750	10.031

find $\frac{dy}{dx}$ *and* $\frac{d^2y}{dx^2}$ at x=1.1

b) Compute the value of π from the formula $\frac{\pi}{4}=\int_0^1 \frac{dx}{1+x^2}$ using trapezoidal rule with 10 sub intervals. 7

18 a) The velocity v (km/min) of a moped which starts from rest is given at fixed intervals of time t (min) as follows:

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

7

Estimate approximately, the distance covered in 20 minutes using Trapezoidal formula.

b) Compute the value of $\int_{0.2}^{1.4} (\sin x - log x + e^x)\, dx$ using Simpson's $\frac{3}{8} th\ rule$. 7

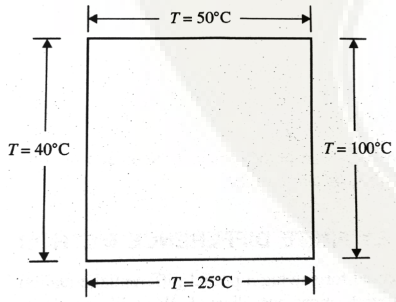
Module V

19 a) Given that $\frac{dy}{dx} = 1 + xy$, $y(0) = 2; y(0.1) = 2.1103; y(0.2) = 2.2430;$ $y(0.3) = 2.4011$, find y(0.4) by Adam-Bashforth-Moulton predictor-corrector method. 6

b) Apply Classical Runge-Kutta fourth order method to find approximate value of y for $x = 0.2$ in steps of 0.1, if $\frac{dy}{dx} = x + y^2$, given that $y = 1\ where\ x = 0$. 8

20 a) Using Euler's modified method, $\frac{dy}{dx} = x + y,\ with\ y(0) = 1,\ and\ x = 0.05$ solve 4

b) A metal plate (1m x 1m) is placed such that its four edges are kept at different temperatures as shown in the figure. The steady state temperature distribution in the plate is given by the Laplace equation: $\frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2} = 0$. Choosing square meshes of width 0.25 m, find the temperature (correct to integer values) of the 9 grid points inside the plate. 10



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Syllabus

Module 1 (7 hours)

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

Module 2 (7 hours)

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

Module 3 (6 hours)

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

Module 4 (6 hours)

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

Module 5 (9 hours)

Numerical solution of ordinary differential equations. Euler and modified Euler methods - Runge–Kutta methods (2nd order and 4th order only) - multistep methods - Adam-Bashforth& Adam-Moulton formulas. Solution of boundary value problems in ordinary differential equations - finite difference methods for solving two dimensional Laplace's equation for a rectangular region - finite difference method of solving heat equation and wave equation with given initial and boundary conditions.

Text Books:

1. William L. Luyben, Process Modeling Simulation and Control for Chemical Engineers-McGraw-Hill (1999).
2. B. Wayne Bequette, Process Dynamics_-Modeling, Analysis and Simulation-Prentice Hall (1998)

Reference Books

1. Steven Chapra and Raymond Canale, Numerical Methods for Engineers, 8th Edition, Mc Graw Hill.
2. Ajay K. Ray, Mathematical Methods in Chemical & Environmental Engineering, Thomson-Learning
3. Froberg C.E., Introduction to Numerical Analysis, Addison Wesley
4. Gerald C.F., Applied Numerical Analysis, Addison Wesley
5. Hildebrand F.B., Introduction to Numerical Analysis, T.M.H.
6. James M.L., Smith C.M. & Wolford J.C., Applied Numerical Methods for Digital Computation, Harper & Row
7. Mathew J.H., Numerical Methods for Mathematics, Science and Engineering, P.H.I

Course Contents and Lecture Schedule

Sl.No	Topic	No. of Lectures
1	**Module I (7 Hours)**	
1.1	Errors in numerical calculations, Sources of errors, significant digits and numerical instability.	1
1.2	Numerical solution of polynomial and transcendental equations - bisection method - method of false position - Newton-Raphson method - fixed-point iteration - rate of convergence of these methods -	4
1.3	Iteration based on second degree equation - the Graeffe's–root squaring method for polynomial equations.	1
1.4	Bairstow's method for quadratic factors in the case of polynomial equations.	1
2	**Module II (7 Hours)**	
2.1	Solutions of system of linear algebraic equations. Direct methods - gauss and gauss - Jordan methods - Crout's reduction method - error analysis -	2
2.2	Iterative methods - Jacobi's iteration - Gauss-seidel iteration - the relaxation method - convergence analysis.	2
2.3	Solution of system of nonlinear equations by Newton-Raphson method.	2
2.4	Power method for the determination of Eigen values - convergence of power method	1
3	**Module III (6 Hours)**	
3.1	Polynomial interpolation. Lagrange's interpolation polynomial -	2
3.2	Divided differences Newton's divided difference interpolation polynomial - error of interpolation -	2
3.3	Finite difference operators - Gregory – Newton forward and backward interpolations - Stirling's interpolation formula.	2
4	**Module IV (6 Hours)**	
4.1	Numerical differentiation - differential formulas in the case of equally	2

	spaced points.	
4.2	Numerical integration - trapezoidal and Simpson's rules.	2
4.3	Gaussian integration - errors of integration formulas	2
5	**Module V (9 Hours)**	
5.1	Numerical solution of ordinary differential equations - Euler and modified Euler methods - Runge–Kutta methods (2nd order and 4th order only).	3
5.2	Multistep methods - Adam-Bashforth& Adam-Moulton formulas.	1
5.3	Solution of boundary value problems in ordinary differential equations - finite difference methods for solving two dimensional Laplace's equation for a rectangular region.	2
5.4	Finite difference method of solving heat equation and wave equation with given initial and boundary conditions	3

CHT342	MATERIAL SCIENCE AND ENGINEERING	CATEGORY	L	T	P	CREDIT
		PEC	2	1	0	3

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

Prerequisite: A basic knowledge in physics and chemistry.

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

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

Mapping of course outcomes with program outcomes

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

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	10
Understand	20	20	20
Apply	20	20	70
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

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

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

Course Level Assessment Questions

Course Outcome 1 (CO1): Define qualitatively the structure and bonding schemes of solids.

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

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

1. Compare isotropy and anisotropy
2. Differentiate between ductility and malleability
3. Explain the technological properties of solid materials

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

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

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

1. Write a note on aluminium and its alloys
2. Classify ceramic and non-ceramic structures

3. List some materials used for high temperature applications

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

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

Model Question Paper

QP CODE: **PAGES:2**

Reg No:______________
Name :______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
SIXTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR
Course Code: CHT 342

Max. Marks: 100
Duration: 3 Hours

MATERIAL SCIENCE AND ENGINEERING
(2019-Scheme)
PART A

(Answer all questions , each question carries 3 marks)

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

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

Module - I

11. Describe the various bonding patterns in solids

12. Explain with neat sketches the 14 Bravais lattices in a cubic crystal lattice.

Module - II

13. (a) Write a note on the mechanical properties of engineering materials.

    (b) Distinguish between paramagnetism and ferromagnetism

14. (a) Describe stress-strain relationship using suitable diagram.

    (b) Define Poisson's ratio.

Module -III

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

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

Module -IV

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

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

Module -V

19. Describe the mechanism and factors influencing corrosion

20. Explain the factors affecting the selection of materials.

(14x5 =70)

Syllabus

Module 1 :Crystal Structure (5 hours)

Structure of atom-present concept of atom-Rutherford's and Bhor's model, Bonding in solids-Types of solids-crystalline and amorphous solids-crystal systems - Bravais lattices-miller indices-coordination number-crystal defects-determination of crystal structure-X-ray diffraction-electron diffraction methods.

Module 2: **Properties of Engineering Materials (8 hours)**

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

Module 3 : Solid solutions (8 hours)

Solid solutions-types of solid solutions-Hume Rothery rules-intermediate phases-mechanical mixtures-phase diagrams-eutectic systems- peritectic system, eutectoid and peritectoid systems - carbon diagram-T-T-T diagram-plastic deformation-recrystallisation-hot and cold working of metals, Heat treatments-elementary study of various metals and alloys like cast iron,carbon steel,alloy steels.

Module 4 : Alloys and Composites (7 hours)

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

Module 5: Selection of Materials (7 hours)

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

Text Books

1. Khanna O.P., A Text Book of Material Science & Metallurgy, Dhanpat Rai publishers
2. Hajra Choudhary, Material Science & Processes, Dhanpat Rai publishers

Reference Books

1. Van Vlack, Elements of Material Science, Pearson publishers
2. Material Science and Engineering, William F. Smith, Javad Hashemi, Ravi Prakash, Mc Graw Hill
3. Material Science and Engineering, Nehal Dash Kaushik Kumar, Apurba Kumar Roy, Wiley
4. Callister's Material Science and Engineering, R. Balasubramaniam, Wiley

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Crystal Structure (5 hours)**	
1.1	Structure of atom-present concept of atom-Rutherford's and Bhor's model	1
1.2	Bonding in solids- Types of solids-crystalline and amorphous solids-crystal systems	2
1.3	Bravais lattices-miller indices-coordination number-crystal defects-determination of crystal structure-X-ray diffraction-electron diffraction methods	2
2	**Properties of Engineering Materials** (8 hours)	
2.1	Mechanical properties -isotropy and anisotropy-elasticity, plasticity, toughness, resilience, tensile strength, ductility, malleability, brittleness, hardness, fatigue, creep, wear resistance	2
2.2	Poisson's ratio-stress-strain relation-true stress and true strain-electrical and magnetic properties-resistivity -conductivity-ionic and electrical conductivity, semiconductors, superconductivity, insulators	2
2.3	Ferroelectricity, piezoelectricity, magnetization, paramagnetism, ferromagnetism, and diamagnetism	2
2.4	Technological properties-castability, machinability, weldability, solderability, workability, formability	2
3	**Solid Solutions (8 hours)**	
3.1	Solid solutions-types of solid solutions-Hume Rothery rules-intermediate phases-mechanical mixtures	1
3.2	Phase diagrams-eutectic systems-peritectic system	1
3.3	Eutectoid and peritectoid systems	1
3.4	Iron - carbon diagram-T-T-T diagram	2
3.5	Plastic deformation-recrystallisation-hot and cold working of metals	1

3.6	Heat treatments-elementary study of various metals and alloys like cast iron,carbon steel,alloy steels.	2
4	**Alloys and Composites (7 hours)**	
4.1	Non-ferrous metals and alloys-aluminium and its alloys-copper and its alloys	1
4.2	Non ferrous metals and alloys used for high temperature services and nuclear application	2
4.3	Organic polymers and its properties-ceramics-classification-comparison of ceramic and non-ceramic structures-	2
4.4	Properties and application of ceramics-composite materials-classification-general characteristics. Introduction to nanomaterials.	2
5	**Selection of Materials (7 hours)**	
5.1	Corrosion-different types, mechanism and factors influencing corrosion	2
5.2	Corrosion prevention-inhibitors and their applications-oxidation-aging of rubber-oxidation of metals and radiation damage	2
5.3	Factors affecting the selection of materials for engineering purposes selection of suitable materials for construction in chemical industry.	3

CHT352	OPERATIONS RESEARCH	CATEGORY	L	T	P	CREDIT
		PEC	2	1	0	3

Preamble: Operational Research (OR) is a discipline to aid decision making and improving efficiency of the system by applying advanced analytical methods. The tools of Operational Research are not from any one discipline; rather Mathematics, Statistics, Information Technology, Economics, Engineering, etc. have contributed to this discipline of knowledge. This course aims at familiarizing the students with quantitative tools and techniques, which are frequently applied to business decision-making and to provide a formal quantitative approach to problem solving and an intuition about situations where such an approach is appropriate.

Prerequisite: Nil

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

CO 1	Recognize the importance and value of Operations Research and mathematical modelling to optimally solve a wide variety of engineering and management problems.
CO 2	Formulate Linear Programming models and apply operations research techniques and algorithms to solve LP problems.
CO 3	Understand the concept of duality and conduct post optimal analysis
CO 4	Formulate transportation, assignment problems and drive their optimal solution.
CO 5	Formulate Network models and apply operations research techniques and algorithms to solve Network problems.

Mapping of course outcomes with program outcomes

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

Assessment Pattern

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

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

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

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

Course Level Assessment Questions

Course Outcome 1 (CO1): Recognize the importance and value of Operations Research and mathematical modelling to optimally solve a wide variety of engineering and management problems.

1. Define Operations research. Write any two area of feasible application of OR.
2. Explain different phases of Operation Research.
3. Write down the basic structure of a linear programming problem in the mathematical form.
4. Write down the applications of OR with examples.

Course Outcome 2 (CO2): Formulate Linear Programming models and apply operations research techniques and algorithms to solve these LP problems.

1. Solve the following problem by Simplex method and comment on the result.
   Maximize: Z = 5X1 +3X2
   Subject to: $4X_1 - X_2 \leq 10$; $2X_1 + 2X_2 \leq 50$; $X_1, X_2 \geq 0$

2. A pharmaceutical company has 100kg of A, 180kg of B and 120kg of C ingredients available per month. The company can use these materials to make three basic pharmaceutical products namely 5-10-5, 5-5-10 and 20-5-10, where the numbers in each case represent the percentage of weight of A, B and C respectively in each of the products. The cost of these raw materials is as follows.

Ingredients	Cost/kg (Rs.)
A	80
B	20
C	50
Inert	20

   The selling prices of these products are Rs.40.50, Rs.43 and Rs.45/kg respectively. There is a capacity restriction of the company for product 5-10-5 because of which company cannot produce more than 30kg per month. Determine how much of each of the product the company should produce in order to maximize its monthly profit. Use simplex method for solving the problem.
3. Solve the following LPP by simple method:
   Maximize $Z = 3X_1 + 2X_2$
   Subject to: $2X_1 + X_2 \leq 5$, $X_1 + X_2 \leq 3$ and $X_1, X_2 \geq 0$

Course Outcome 3(CO3): Understand the concept of duality and conduct post optimal analysis.

1. Write the dual of the following LPP
   Minimize $Z = 3X_1 - 2X_2 + 6X_3$
   Subject to: $4X_1+5X_2+3X_3 \geq 7$; $3X_1+X_2+6X_3 \geq 5$; $7X_1-2X_2-3X_3 \leq 10$
   $X_1-2X_2+5X_3 \geq 3$; $4X_1+7X_2-9X_3 \geq 2$ and $X_1, X_2, X_3 \geq 0$
2. Use penalty (Big-M) method to solve the LP problem below.
   Minimize $Z = 5X_1+3X_2$
   Subject to: $2X_1+4X_2 \leq 12$; $2X_1+2X_2 = 10$; $5X_1+2X_2 \geq 10$; X_1 and $X_2 \geq 0$
3. Use two-phase simplex method to solve the following LP problem.
   Maximize $Z = 3X_1+2X_2+2X_3$
   Subject to $5X_1+7X_2+4X_3 \leq 7$; $-4X_1+7X_2+5X_3 \geq -2$
   $3X_1+4X_2-6X_3 \geq 29/7$; X_1, X_2 and $X_3 \geq 0$
4. State the general rules for formulating a dual LP problem from its primal. Write the dual to the following LP problem.
   Maximize $Z = X_1 - X_2 + 3X_3$
   Subject to Constraints:
   $X_1 + X_2 + X_3 \leq 10$
   $2X_1 - X_3 \leq 2$
   $2X_1 - 2X_2 - 3X_3 \leq 6$ and $X_1, X_2, X_3 \geq 0$

Course Outcome 4 (CO4): Formulate transportation, assignment problems and drive their optimal solution.

1. Raw materials from four different warehouses are to be transported to five different plants. The availability at each of the warehouses is 25, 30, 20 and 30 tons

respectively. The demands in the corresponding plants are 20,20,30,10 and 25 tons. It is not possible to ship the raw material from warehouse 4 to plant 4. From the unit cost of transportation given below, find the initial basic feasible solution using least cost cell method.

		1	2	3	4	5	Supply
Source	1	10	2	3	15	9	25
	2	5	10	15	2	4	30
	3	15	5	14	7	15	20
	4	20	15	13	…	8	30
Demand		20	20	30	10	25	105

2. A Computer Centre has three expert programmers. The centre wants three application programs to be developed. The head of the Computer Centre, after studying carefully the programmes to be developed, estimates the computer time in minutes required by the experts for the application programmes as follows:

		Programmers		
		A	B	C
Programmes	1	120	100	80
	2	80	90	110
	3	110	140	120

Assign the programmers to the programmes in such a way that the total computer time is minimum.

Course Outcome 5 (CO5): Formulate Network models and apply operations research techniques and algorithms to solve these Network problems.

1. Define following terms with respect to CPM/PERT: event, merge event, burst, event, activity, processor activity, successor activity, dummy activity.
2. The flow capacities in a pipe network are shown in table below. Find the maximal flow from node 1 to node 6.

To		1	2	3	4	5	6
From	1	...	30	60	15	...	...
	2	20	...	20	25	5	...
	3	40	15	...	20	...	50
	4	25	20	40	...	10	35
	5	...	10	...	40	...	30
	6	...	...	40	35	30	...

3. The details of a project consisting of activities A to K are summarized in table below.

Activity	Immediate Predecessor(s)	Duration	Activity	Immediate Predecessor(s)	Duration
A	...	7	G	C	3
B	...	3	H	E, F	4
C	...	4	I	E, F	5
D	A	2	J	D, H	6
E	A, B	3	K	I, G	3
F	C	5			

Construct the CPM network, determine the critical path and project completion time.

Model Question paper

QP CODE: **PAGES: 3**

Reg No: _______________ **Name: ____________________________**

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SIXTH SEMESTER B. TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: CHT 352

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

OPERATIONS RESEARCH

PART – A

Answer All the Questions (10 x 3 = 30)

1. Define Operations research. Write any two area of feasible application of OR.
2. Explain different phases of Operation Research.
3. Explain clearly the following terms in LPP.
   i. Objective function
   ii. Decision Variables
   iii. Slack and Surplus Variables
4. Explain the term duality in linear programming.
5. Write the dual of the following LPP
   Minimize $Z = 3X_1-2X_2+6X_3$
   Subject to: $4X_1+5X_2+3X_3 \geq 7$; $3X_1+X_2+6X_3 \geq 5$; $7X_1-2X_2-3X_3 \leq 10$
   $X_1-2X_2+5X_3 \geq 3$; $4X_1+7X_2-9X_3 \geq 2$ and $X_1, X_2, X_3 \geq 0$
6. Describe Big-M method. Explain when do you prefer to use it.
7. Differentiate between Transportation and Transhipment problem
8. List different time estimates used with reference to PERT. Write the expressions for expected duration of a project, and its standard deviation.
9. Differentiate between PERT and CPM.
10. Explain the conditions under which crashing of project is necessary. Write its effect on the project cost.

PART – B

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

Module 1

11. (a) Maximize $Z = 10X_1 + 15X_2$ Subject to constraints,

$2X_1 + X_2 \leq 26$; $2X_1 + 4X_2 \leq 56$;

$X_1 - X_2 \geq -5$,

$X_1, X_2 \geq 0$

(b) Maximize $Z = 40X_1 + 35X_2$ Subject to constraints,

$2X_1 + 3X_2 \leq 60$,

$4X_1 + 3X_2 \leq 96$,

$X_1, X_2 \geq 0$

OR

12. (a) Use the graphical method to solve the following LP problem.

Maximize $Z=2X_1+X_2$subject to the constraints:

$X_1 + 2X_2 \leq 10$

$X_1 + X_2 \leq 6$

$X_1 - X_2 \leq 2$

$X_1 -2X_2 \leq 1$ and

$X_1, X_2 \geq 0$

(b) The manager of an oil refinery decides on the optimal mix of two possible blending processes of which the inputs and outputs per production run are as follows

Process (units)	Input (units)		Output (units)	
	Crude A	Crude B	Gasoline X	Gasoline Y
1	5	3	5	8
2	4	5	4	4

The maximum amount available for crude A and B are 200 units and 150 units respectively. Market requirements shows that at least 100 units of gasoline X and 80 units of gasoline Y must be produced. The profit per production run for processes 1 and 2 are Rs.300 and Rs.400 respectively. Formulate the LP problem.

Module 2

13. (a) Use penalty (Big-M) method to solve the LP problem below.

Minimize $Z = 5X_1+3X_2$

Subject to: $2X_1+4X_2 \leq 12$; $2X_1+2X_2 = 10$; $5X_1+2X_2 \geq 10$; X_1 and $X_2 \geq 0$

OR

14. Use two-phase simplex method to solve the following LP problem.

Maximize $Z = 3X_1+2X_2+2X_3$

Subject to $5X_1+7X_2+4X_3 \leq 7$

$-4X_1+7X_2+5X_3 \geq -2$

$3X_1+4X_2-6X_3 \geq 29/7$; X_1, X_2 and $X_3 \geq 0$

Module 3

15. State the general rules for formulating a dual LP problem from its primal. Write the dual to the following LP problem.

Maximize $Z = X_1 - X_2 + 3X_3$

Subject to Constraints:

$X_1 + X_2 + X_3 \leq 10$

$2X_1 - X_3 \leq 2$

$2X_1 - 2X_2 - 3X_3 \leq 6$ and

$X_1, X_2, X_3 \geq 0$

OR

16. Write the dual of the following linear programming problem.

Minimize, $Z = 20X_1 + 23X_2$

Subjected to:

$- 4X_1 - X_2 \leq -8$

$5X_1 - 3X_2 = - 4$

$X_1, X_2 \geq 0$

Solve the Dual problem using simplex method and predict the value of variables X_1 and X_2 from the solution of dual linear programming problem.

Module 4

17. A manufacturing company has three factories, F1, F2 and F3, and two retail outlets, R1 and R2. It wishes to transport its products from its factories to its outlets at minimum total cost. The table below gives details of demand and supply, and also the unit costs of transportation.

		Retail outlet		
		R1	R2	Supply
Factories	F1	2	6	30
	F2	2	4	60
	F3	6	9	20
	Demand	60	20	

(i) Prepare the North-West corner rule solution for the balanced form of this problem.

(ii) Check the optimality of the solution and comment on it.

OR

18. A Computer Centre has three expert programmers. The centre wants three application programs to be developed. The head of the Computer Centre, after studying carefully the programmes to be developed, estimates the computer time in minutes required by the experts for the application programmes as follows:

		Programmers		
		A	**B**	**C**
Programmes	**1**	120	100	80
	2	80	90	110

	3	110	140	120

Assign the programmers to the programmes in such a way that the total computer time is minimum.

Module 5

19. The flow capacities in a pipe network are shown in table below. Find the maximal flow from node 1 to node 6.

To		**1**	**2**	**3**	**4**	**5**	**6**
From	**1**	...	30	60	15	...	...
	2	20	...	20	25	5	...
	3	40	15	...	20	...	50
	4	25	20	40	...	10	35
	5	...	10	...	40	...	30
	6	...	...	40	35	30	...

OR

20. The details of a project consisting of activities A to K are summarized in table below.

Activity	**Immediate Predecessor(s)**	**Duration**	**Activity**	**Immediate Predecessor(s)**	**Duration**
A	...	7	G	C	3
B	...	3	H	E, F	4
C	...	4	I	E, F	5
D	A	2	J	D, H	6
E	A, B	3	K	I, G	3
F	C	5			

Construct the CPM network, determine the critical path and project completion time.

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Syllabus

Module 1 (8 Hrs.)

Introduction to Operations Research: Introduction to OR models, Linear programming - Typical Applications of Linear programming problems, Problem formulation, Graphical and Algebraic method solutions of LPP, Simplex method for LPP.

Module 2 (7 Hrs.)

Special cases in simplex method: Big-M method, Two Phase simplex method, Degeneracy, Multiple solutions, Unbounded solutions, Infeasible solutions, Sensitivity Analysis: Graphical and algebraic approaches.

Module 3 (6 Hrs.)

Duality and Post-optimal analysis: Dual of an LP, Primal-Dual relationships, Economic interpretation of duality, Dual Simplex method, Generalised simplex algorithm, Post-optimal analysis, Changes affecting feasibility and changes affecting optimality.

Module 4 (7 Hrs.)

Transportation model and its variants: Definition, non-traditional transportation models, Transportation algorithm: Determination of the starting solution and iteration computations, Simplex method explanation of method of multipliers, Assignment model: Hungarian method and its simplex explanation.

Module 5 (7 Hrs.)

Network models: Scope and definition, Minimal spanning tree algorithm, Shortest route problem, maximum flow model, CPM and PERT: Network representation, Critical path computation, construction of the time schedule, LP formulation of CPM, PERT calculations.

Text Books

1. Hamdy A. Taha, "Operations Research, an introduction", Eighth Edition, Prentice Hall of India, 2003.
2. Edgar T. F., Himmelblau D. M., Optimisation of Chemical Processes, McGraw Hill.

Reference Books

1. Miller D.M. and Schmidt J. W., Industrial Engineering and Operations Research, John Wiley and Sons, Singapore, 1990.
2. Shennoy G.V. and Srivastava U.K., "Operation Research for Management", Wiley Eastern, 1994.
3. Bazara M.J., Jarvis and Sherali H., "Linear Programming and Network Flows", John Wiley, 1990.
4. Philip D.T. and Ravindran A., "Operations Research", John Wiley, 1992.
5. Hillier and Liebermann, "Operations Research", Holden Day, 1986
6. Budnick F.S., "Principles of Operations Research for Management", Richard D Irwin, 1990.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Introduction to Operations Research (8 Hrs.)**	
1.1	Introduction to OR models, Linear programming - Typical Applications of Linear programming problems	2
1.2	Problem formulation	2
1.3	Graphical method solutions of LPP	1
1.4	Algebraic method solutions of LPP	1
1.5	Simplex method for LPP	2
2	**Special cases in simplex method (7 Hrs.)**	

2.1	Big-M method	2
2.2	Two Phase simplex method	1
2.3	Degeneracy, Multiple solutions	1
24	Unbounded solutions, Infeasible solutions	1
2.5	Sensitivity Analysis: Graphical and algebraic approaches	2
3	**Duality and Post-optimal analysis (6 Hrs.)**	
3.1	Dual of an LP, Primal-Dual relationships	1
3.2	Economic interpretation of duality	1
3.3	Dual Simplex method	1
3.4	Generalised simplex algorithm	1
3.5	Post-optimal analysis	1
3.6	Changes affecting feasibility and changes affecting optimality	1
4	**Transportation model and its variants (7 Hrs.)**	
4.1	Definition, non-traditional transportation models	1
4.2	Transportation algorithm: Determination of the starting solution and iteration computations	2
4.3	Simplex method explanation of method of multipliers	2
4.4	Assignment model: Hungarian method and its simplex explanation	2
5	**Network models (7 Hrs.)**	
5.1	Scope and definition	1
5.2	Minimal spanning tree algorithm	1
5.3	Shortest route problem	1
5.4	Maximum flow model	1
5.5	CPM and PERT: Network representation, Critical path computation	1
5.6	Construction of the time schedule	1
5.7	LP formulation of CPM, PERT calculations.	1

CHT 362	PROCESS INSTRUMENTATION	CATEGORY	L	T	P	CREDIT
		PEC	2	1	0	3

Preamble: This course covers the key aspects of chemical process instrumentation. The course will provide a comprehensive introduction to principles and practices of measurement of important chemical process variables such as pressure, temperature, flow, level, density, viscosity, humidity etc.

Prerequisite: NIL

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

CO 1	Explain the functional elements of measurement systems, the classification of Instruments and calibration of various instruments.
CO 2	Understand the basic fundamentals, terms, and units of pressure, temperature, density, viscosity, humidity, level, and flow rate.
CO 3	Identify, select and install commonly used process variable measurement devices for a specified purpose.
CO 4	Illustrate the construction and working principle of various type of instruments to measure physical quantities like pressure, temperature, density, viscosity, humidity, level, and flow rate.
CO 5	Explain and sketch various measuring instruments used for density, viscosity, humidity and their safe application.

Mapping of course outcomes with program outcomes

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

Assessment Pattern

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

Analyse	10	10	20
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

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

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

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Course Level Assessment Questions

Course Outcome 1 (CO1): Explain the functional elements of measurement systems, the classification of Instruments and calibration of various instruments.

1. Explain the significance of the primary and secondary elements of an instrument.
2. Explain static and dynamic characteristics of an instrument.
3. Explain different types of direct & indirect level measurement techniques

Course Outcome 2 (CO2): Understand the basic fundamentals, terms, and units of pressure, temperature, density, viscosity, humidity, level, and flow rate.

1. List different temperature scales and their relations with each other.
2. Define and explain terms: (1) Gauge pressure (2) Absolute pressure (3) Static pressure.
3. What are the different units of pressure and what do you mean by force summing device?

Course Outcome 3(CO3): Identify, select and install commonly used process variable measurement devices for a specified purpose.

1. Describe any two instruments that are used for low pressure measurement.
2. Give justification for why you would choose a venturi-meter over an orifice meter for measuring flow of a fluid that has to be transported over long distances.
3. Suggest a pressure gauge for measuring the pressure in the range of 650kg/cm^2 to 16500 kg/cm^2. Explain the working of the same

Course Outcome 4 (CO4): Illustrate the construction and working principle of various type of instruments to measure physical quantities like pressure, temperature, density, viscosity, humidity, level, and flow rate.

1. Explain the working principle of McLeod Gauge with neat sketch & list the merits & demerits.
2. With neat sketch explain construction and working of Rotameter
3. With a neat diagram, explain the working of radiation pyrometer. List out the advantages and disadvantages of radiation pyrometer.

Course Outcome 5 (CO5): Explain and sketch various measuring instruments used for density, viscosity, humidity and their safe application.

1. Briefly describe about the construction and working principle of Ultrasonic densitometer.
2. Explain the working principle of the hair-tension hygrometer with the help of aneat figure.
3. Explain the different types of viscometer.

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Model Question Paper

QP CODE: PAGES: 3

Reg No: ______________ Name: ______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SIXTH SEMESTER B. TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: CHT 362

Max. Marks: 100 Duration: 3 Hours

PROCESS INSTRUMENTATION

PART – A

Answer All the Questions (10 x 3 = 30)

1. Define and explain terms: (1) Hysteresis (2) Reproducibility (3) Resolution
2. Explain the roles of a functioning element
3. Describe any two instruments that are used for low pressure measurement
4. List the advantages & disadvantages of McLeod Gauge.
5. List different temperature scales and their relations with each other
6. List the ranges and accuracy of any five types of temperature measuringinstruments.
7. Explain different types of open channel flow measurements.
8. Classify mechanical flow meters.
9. Differentiate kinematic viscosity from specific viscosity.
10. What is psychrometer? How does it differ from hygrometer?

PART – B

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

Module 1

11 a) How do instruments respond to continuous change in process parameters? Explain each Characteristic.

b) Explain about various sources of static error. **(10+4 = 14 marks)**

OR

12 a)With a neat figure, explain the functional elements of an instrument with a suitable example. **(14 marks)**

Module 2

13. Explain the working principle of McLeod Gauge with neat sketch & list the merits & demerits. **(14 marks)**

OR

14 a) Explain the working principle of Knudsen gauge with a neat sketch.

b) Explain the working principle of diaphragm gauge used for pressure measurement with a neat figure. **(7+7=14 marks)**

Module 3

15 a) Explain the construction and working of bimetallic thermometer with a neat sketch. List different materials used for the construction of bimetallic thermometer

b) Explain the sources of errors and precautions to be taken in temperature measurements using liquid filled thermometers. **(7+7=14 marks)**

OR

16. With a neat diagram, explain the working of radiation pyrometer. List out the advantages and disadvantages of radiation pyrometer.

(14 marks)

Module 4

17.a)With the help of neat labelled diagrams, explain the working principle and applications of the pitot tube for flow velocity measurement.

b) Differentiate variable area meters & variable head meters with examples for each.

(10+4=14 marks)

OR

18. a) With the help of a figure describe the working of bubbler system for level mesurement

b)Explain working of ultrasonic level detectors.

(7+7=14 marks)

Module 5

19. Illustrate with neat sketch about Saybolt Viscometer. **(14 marks)**

OR

20. Describe the principle of humidity measurement and also explain the working principle of any one type of hygrometer with neat sketch. **(14 marks)**

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Syllabus

Module 1 (6 hours)

Principles of measurements and classification of process instruments, Functional elements of instruments, Basic methods of measurements, static and dynamic characteristics of measurement system,Errors in measurement, Calibration- Methods of Calibration-Calibration Procedures, Introduction to Data acquisition systems: objectives of DAS, elements of analog DAS, elements of digital DAS.

Module 2 (7 hours)

Units of pressure, Measurement of pressure-Manometers, Bourdon gauges, Diaphragm gauges, Bellow gauges, Bell gauges, Electrical methods:- Elastic elements with LVDT and strain gauges, Capacitive type pressure gauge:- Piezo resistive pressure sensor-Resonator pressure sensor Vaccum gauges:- McLeod gauge, Knudsen gauge, Pirani gauge, thermocouple gauge, ionization gauge, Calibration of pressure gauges.

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Module 3 (7 hours)

Measurement of temperature: Temperature scales, Temperature standard, Bimetallic thermometer, filled-in thermometers, Sources of errors in - filled in systems and their compensation,vapour pressure thermometers, resistance thermometers, thermistors, thermocouples - types and ranges - characteristics, laws of thermocouples, thermowell, radiation pyrometer, optical pyrometer, temperature transmitter.

Module 4 (9 hours)

Measurement of flow: Variable head flow meters:- orifice plate, venturi tube, dahl tube, flow nozzle, pitot tube, Variable Area flow meter:-Rotameter,Mass flow meter - Angular momentum, Coriolis type mass flow meters, Positive displacement flow meters:- Nutating disc, Reciprocating piston and Oval gear flow meters, Turbine flow meter.Electromagnetic flow meter:- Ultrasonic flow meters, Laser Doppler anemometer ,Vortex shedding flow meter, Open channel flow measurements, Solid flow measurement.
Measurement of level: Sight glass, float gauge, displacer, torque tube, bubbler tube, diaphragm box, D/P methods, electrical methods - resistance type, capacitance type, ultrasonic level gauging. Boiler drum level measurement:- Differential pressure method and Hydrastep method, Solid level measurement

Module 5 (6 hours)

Units of density and specific gravity, Baume scale and API scale,Pressure type densitometers, Float type densitometers , Ultrasonic densitometer, gas densitometer.
Measurement of Viscosity:-Saybolt viscometer-Rotameter type viscometer, Consistency meters
Measurement of Humidity:- Dry and wet bulb psychrometers, Resistive and capacitive type hygrometers, Dew cell , Commercial type dew meter, Moisture measurement in solids: Conductivity sensor, Microwave and IR sensors

Text Books:

1. William C. Dunn, Fundamentals of Industrial Instrumentation and Process Control – 1st Edition, McGraw Hill(2005).
2. Donald P Eckman, Industrial Instrumentation, CBS Publishers and Distributors, New Delhi.

Reference Books:

1. Jain R K, Mechanical and Industrial measurements, Khanna publishers.
2. Patranabis D, Principles of Industrial Instrumentation, Tata- McGraw Hill.
3. Ernest O Doeblin, Measurement systems, Application and Design, McGraw Hill.
5. C.S. Rangan,G.R.Sarma and V.S.V. Mani – Instrumentation Devices and Systems – Tata McGraw Hill.

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Course Contents and Lecture Schedule:

No.	Details	No. of Lectures
1	**Module 1**	**6**
1.1	Principles of measurements and classification of process instruments, Functional elements of instruments	1
1.2	Basic methods of measurements, static and dynamic characteristics of measurement system,	1
1.3	Errors in measurement	1
1.4	Calibration- Methods of Calibration- Calibration Procedures,	1
1.5	Introduction to Data acquisition systems: objectives of DAS, elements of analog DAS, elements of digital DAS.	2
2	**Module 2**	**7**
2.1	Units of pressure, Measurement of pressure-Manometers, Bourdon gauges, Diaphragm gauges, Bellow gauges, Bell gauges.	2
2.2	Electrical methods:- Elastic elements with LVDT and strain gauges,	2
2.3	Capacitive type pressure gauge:- Piezo resistive pressure sensor-Resonator pressure sensor	1
2.4	Vaccumgauges:- McLeod gauge, Knudsen gauge, Pirani gauge, thermocouple gauge, ionization gauge, Calibration of pressure gauges	2
3	**Module 3**	**7**
3.1	Measurement of temperature: Temperature scales, Temperature standard,	1
3.2	Bimetallic thermometer, filled-in thermometers, Sources of errors in -filled in systems and their compensation,	2
3.3	vapour pressure thermometers, resistance thermometers, thermistors,	1
3.4	thermocouples - types and ranges - characteristics, laws of thermocouples, thermowell,	2
3.5	radiation pyrometer, optical pyrometer, temperature transmitter.	1
4	**Module 4**	**9**
4.1	Measurement of flow: Variable head flow meters:- orifice plate, venturi tube, dahl tube, flow nozzle, pitot tube,	1
4.2	Variable Area flow meter:-Rotameter,Mass flow meter - Angular momentum, Coriolis type mass flow meters,	1
4.3	Positive displacement flow meters:-Nutating disc, Reciprocating piston and Oval gear flow meters, Turbine flow meter.	1
4.4	Electromagnetic flow meter:- Ultrasonic flow meters, Laser Doppler anemometer ,Vortex shedding flow meter,	1
4.5	Open channel flow measurements, Solid flow measurement.	1
4.6	Measurement of level: Sight glass, float gauge, displacer, torque tube,	2

	bubbler tube, diaphragm box, D/P methods, electrical methods - resistance type, capacitance type, ultrasonic level gauging.	
4.7	Boiler drum level measurement:- Differential pressure method and Hydrastep method, Solid level measurement	2
5	**Module 5**	**6**
5.1	Units of density and specific gravity, Baume scale and API scale,Pressure type densitometers, Float type densitometers , Ultrasonic densitometer, gas densitometer.	2
5.2	Measurement of Viscosity:-Saybolt viscometer-Rotameter type viscometer, Consistency meters	2
5.3	Measurement of Humidity:- Dry and wet bulb psychrometers, Resistive and capacitive type hygrometers, Dew cell , Commercial type dew meter, Moisture measurement in solids: Conductivity sensor, Microwave and IR sensors	2

CHT372	CATALYST SCIENCE AND CATALYTIC PROCESSES	CATEGORY	L	T	P	CREDIT
		PEC	2	1	0	3

Preamble: The science and technology of catalysis is of great significance as it affects our daily life. Four major sectors of the world economy; petroleum and energy production, chemicals and polymer production, food industry and pollution control, involve catalytic processes. Catalysis involves understanding of the thermodynamics, kinetics, electronic interaction, crystal structure, reactor design and process development for a catalytic process. The Topics included in the course are different types of Catalysis, Thermodynamics of adsorption, reparative methods and Characterisation of catalysts, industrial catalysis and modern trends in catalysis.

Prerequisite: Nil

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

CO 1	Apply the basic concepts & theory for characterization of catalysts.
CO 2	Describe the preparation of catalysts for various unit processes.
CO 3	Explain various catalytic processes in industries.
CO 4	Describe the deactivation of catalysts.
CO 5	Analyse modern trends in catalysis

Mapping of course outcomes with program outcomes

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

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	10
Understand	20	20	20
Apply	20	20	70
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

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

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

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Classify catalysts on the basis of catalytic structure.

2. Describe Langmuir adsorption isotherm in various forms.

3. what are the different steps in catalytic reaction.

Course Outcome 2 (CO2)

1. Describe Sol gel process with a neat sketch and flow charts.

2. Describe co-precipitation with example.

3. What are catalytic agents? Give examples.

Course Outcome 3(CO3):

1. List any three transition metal catalysts with application.

2. List any five industrial application of Zeolite

Course Outcome 4 (CO4):

1. What is the significance of regeneration of catalysts?

2. Describe poisoning method of catalyst deactivation.

Course Outcome 5 (CO5):

1. Describe photo catalytic reaction with an example

2. List the advantages of nano catalysis over conventional catalytic processes.

3. Describe Sintering method of catalyst deactivation.

Model Question paper

QP CODE: **PAGES: 3**

Reg No: _______________ **Name: ___________________________**

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SIXTH SEMESTER B. TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: CHT 372

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

CATALYST SCIENCE AND CATALYTIC PROCESSES

PART – A

Answer All the Questions (10 x 3 = 30)

1. Write notes on catalyst selectivity.
2. Differentiate physisorption & Chemisorption
3. With example explain flame hydrolysis.
4. Mention industrial application of zeolite.
5. What are catalytic promoters.
6. Define Bragg's law.
7. What you mean by deactivation of catalyst.
8. What is sintering of catalysts.
9. Give any three examples for biocatalysts.
10. What are the types of phase transfer catalysis.

PART B

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

Module -I

11. a)Explain any two adsorption isotherms. (10 marks)

b) explain different steps involved in heterogenous catalytic reaction.(4marks)

12. a).write the general characteristics of catalysis (7marks)

b). explain classification of catalysts. (7marks)

Module -II

13 a). Describe precipitation & co-precipitation method of catalyst preparation with suitable examples. (7marks)

b). Explain sol gel method of catalyst synthesis with necessary steps, and suitable example. (7marks)

14. a).Explain chemical vapour decomposition technique with example. (7marks)

b). Explain zeolite preparation. Mention its uses as a catalysts. (7marks)

Module -III

15. a).Explain BET method to find the surface area of catalysts. (7marks)

b).Explain XRD for catalyst characterization. (7marks)

16. a).Explain Chemisorption techniques for catalyst characterization. Classify the method according to gases used. (6marks)

b). State the importance of catalyst characterization. Classify different characterization methods. (7marks)

Module -IV

17. a). Describe on catalyst deactivation? Classify based on mechanisms. (6marks)

b). Explain the mechanism of coke formation on catalysts with neat sketches. (8marks).

18. a). Explain regeneration of deactivated catalysis. (9marks)

b). Explain coke formation on catalysts. (5marks)

Module -V

19. a). Explain transition metal catalysts & list any two industrial application. (7marks)
b). Explain the different transfer catalysis with industrial application. (7marks)

20. a). Differentiate homogenous & heterogenous catalysis. Explain any two heterogenous catalysts with industrial application. (7marks)

b). describe bio catalysis & phocatalysis with industrial application. (7marks)

Syllabus

Module 1 (6 Hrs.)

General characteristics of catalysis, Classification of Catalyst, Thermodynamics of adsorption, Physical adsorption and chemisorption.

Module 2 (7 Hrs.)

Catalyst preparative Methods-Precipitation and co precipitation, Sol gel process, Flame hydrolysis, Supported catalyst from CVD and related techniques, methods preparation and structure of supports, Synthesis of aluminosilicate zeolites.

Module 3 (7 Hrs.)

Catalyst Characterisation- surface area measurements, BET theory, Pore size distribution, Porosimetry, Chemisorption techniques, Static and dynamic methods, Crystallography and surface analysis techniques – XRD, NMR.

Module 4 (7 Hrs.)

Deactivation -classification of catalyst deactivation processes. poisoning of catalysts, poisoning of metallic catalysts, poisoning of non-metallic catalysts, poisoning of bifunctional catalysts, coke formation on catalysts, metal deposition on catalysts ,sintering of catalysts. Regeneration of deactivated catalyst.

Module 5 (8 Hrs.)

Industrial catalysis -Homogeneous, Heterogeneous catalysis, Biocatalysts and their typical industrial applications. Transition metal catalyst, Organo-metallic catalyst, Dual function catalyst, Zeolite and their typical industrial applications. Modern trends in catalysis – Phase transfer catalysis, electro catalysis, Nano catalysis, Polymer supported catalysis, Bio catalysis, Photo catalysis.

Text Books

- Smith, J.M, Chemical Engineering Kinetics, McGraw Hill 2.

Reference Books

1. B. Viswanathan, S. Sivasanker A. V. Ramaswamy, Catalysis: Principles and Applications, Academic Press
2. Diazo Kunii, and Octave Levenspiel, Fluidization Engineering, Butterworth Heinemann
3. Fogler H.S, Elements of Chemical Reaction Engineering, Prentice Hall of India
4. Levenspiel O, Chemical Reaction Engineering, John Wiley.
5. Emmett, P.H , Catalysis Vol I and II, Reinhold Corp, New York, 1954
6. Hill C.G., An Introduction to Chemical Engineering Kinetics & Reactor Design, John Wiley

7. Thomas and Thomas , Introduction to Heterogeneous Catalysis, Academic Press, London, 1967

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Module 1 (6 Hrs.)**	
1.1	General characteristics of catalysis, Classification of Catalyst	2
1.2	Thermodynamics of adsorption, Physical adsorption and chemisorption.	2
1.3	Adsorption isotherms. Catalyst selectivity.	2
2	**Module 2 (7 Hrs.)**	
2.1	Catalyst preparative Methods- Precipitation and co precipitation, Sol gel process	2
2.2	Flame hydrolysis, Supported catalyst from CVD and related techniques,	3
2.3	methods preparation and structure of supports, Synthesis of aluminosilicate zeolites.	2
3	**Module 3 (7 Hrs.)**	
3.1	Catalyst Characterisation- surface area measurements, BET theory, Pore size distribution, Porosimetry	3
3.2	Chemisorption techniques, Static and dynamic methods	2
3.3	Crystallography and surface analysis techniques – XRD, NMR.	2
4	**Module 4 (7 Hrs.)**	
4.1	Deactivation -classification of catalyst deactivation processes.	1
4.2	poisoning of catalysts, poisoning of metallic catalysts, poisoning of non-metallic catalysts, poisoning of bifunctional catalysts,	2
4.3	coke formation on catalysts, metal deposition on catalysts ,sintering of catalysts.	2
4.4	Regeneration of deactivated catalyst.	2
5	**Module 5 (8 Hrs.)**	
5.1	Industrial catalysis -Homogeneous, Heterogeneous catalysis, Biocatalysts and their typical industrial applications	2
5.2	Transition metal catalyst, Organo metallic catalyst, Dual function catalyst, Zeolite and their typical industrial applications	3
5.3	Modern trends in catalysis – Phase transfer catalysis, electro catalysis, Nano catalysis, Polymer supported catalysis, Bio catalysis, Photo catalysis.	3

SEMESTER VI

MINOR

CHT382	HAZARD AND RISK ASSESSMENT	CATEGORY	L	T	P	CREDIT
		VAC	3	1	0	4

Preamble: Chemical Industries are known as the most dangerous and hazardous industries since long.Varieties of conditions are present in chemical industries which may lead to different type of industrial accidents. Most of the industrial accidents are due to the human error or ignorance and responsible for the major losses to the industries and humanity. Itis therefore essential to know about hazards, accidents, safe handling of chemicals, and operation of plant equipment and transportation of chemicals. By taking this course, students will gain a greater ability to identify the various categories of hazards and associated risks in workplaces and apply strategies that are used to make sure hazards and associated risks are eliminated or reduced.

Prerequisite: CHT 282 - Safety Engineering of Process Plants

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

CO1	Identify and assess the risk and hazards of a process and operation.
CO2	Explain different types of indices used in hazard survey.
CO3	Explain different types of hazard identification and risk assessment techniques in the workplace.
CO4	Determine the main process hazard analysis tools used and compare their uses, benefits and limitations.
CO5	Describe how risk assessment steps apply to process safety hazards and define the main concepts related to process safety risk assessment including protection layers, threats, consequences and effects, etc.

Mapping of course outcomes with program outcomes

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

Assessment Pattern

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination**
	1	**2**	
Remember	10	10	20
Understand	20	20	40

Apply	20	20	40
Analyze			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

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

End Semester Examination Pattern:

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

Course Level Assessment Questions

Course Outcome 1 (CO1): Identify and assess the risk and hazards of a process and operation and determine the underlying causes of the hazards.

1. Describe the features of the following: (i) Pool fire (ii) Jet fire (iii) Flash fire and (iv) Deflagration.
2. Explain in detail about classification of hazards in chemical process industries.
3. Explain the major consequences of explosion hazards.

Course Outcome 2 (CO2): Explain different types of indices used in hazard survey.

1. Write notes on: (i) Mond's index (ii) Hazard identification tools (iii) Preliminary hazard analysis.
2. Explain ALARP triangle and give its significance in risk reduction.
3. Explain Dow Fire Index. Write the advantages and disadvantages of Dow Fire Index.

Course Outcome 3 (CO3): Explain different types of hazard identification and risk assessment techniques in the workplace.

1. Describe the HAZOP procedure and list the guide words.
2. Explain Fault tree analysis used in quantifying Risk.
3. Construct an event tree for LPG release from a storage tank located in a LPG bottling plant. Assume frequency values for different situations

Course Outcome 4 (CO4): Determine the main process hazard analysis tools used and compare their uses, benefits and limitations.

1. Explain the salient features of discharge rate models used for consequence modelling.
2. Explain the cause and consequence of BLEVE.
3. A gas with a molecular weight of 30 is used in a particular process. A source model study indicates that for a particular accident outcome 1.0 kg of gas will be released instantaneously. The release will occur at ground level. The plant fence line is 500 m away from the release. Determine: (i) the time required after the release for the center of the puff to reach the plant fence line. Assume a wind speed of 2 m/s, (ii) the maximum concentration of the gas reached outside the fence line.

Course Outcome 5 (CO5): Describe how risk assessment steps apply to process safety hazards and define the main concepts related to process safety risk assessment including protection layers, threats, consequences and effects, etc.

1. Write any five benefits of implementing LOPA.
2. Explain the significance of Probit functions in risk assessment with suitable example.
3. Explain individual risk and societal risk.

****

Model Question Paper

QP CODE: **PAGES: 3**

Reg No: _______________Name: _______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SIXTH SEMESTER B. TECH DEGREE EXAMINATION,MONTH & YEAR

Course Code: CHT 382

Max. Marks: 100 Duration: 3 Hours

HAZARD AND RISK ASSESSMENT

PART – A

Answer All the Questions (10 x 3 = 30)

1. Define Hazard, risk and accident.
2. Explain threshold limit values, Short term exposure limit and ceiling level of toxic gases.
3. One thousand Kilograms of methane escapes from a storage vessel, mixes with airand explodes. Determine the equivalent amount of TNT assuming an explosion efficiency of 2%. The Heat of combustion of methane is 818.7KJ/mol and energy of explosion of TNT is 4686KJ/kg.
4. Name the various factors that contribute to Physical hazard with suitable examples.
5. List the major reasons for Bhopal gas tragedy.
6. List out the major objectives of Bow-tie analysis.
7. Differentiate UFL and LFL.
8. Give the methods of preventing BLEVE in process plants.
9. List different steps involved in risk assessment process.

10. Write any five benefits of implementing LOPA.

PART – B

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

Module 1

11. (a) Describe the features of the following: (i) Pool fire (ii) Jet fire (iii) Flash fire and (iv) Deflagration.
    (b) Explain in detail about classification of hazards in chemical process industries.
    (8 + 6 = 14 Marks)

OR

12. (a) Give the classification and explain the consequences of chemical hazards.
    (b) Explain the major consequences of explosion hazards. **(7 + 7 = 14 Marks)**

Module 1I

13. Write notes on: (i) Mond's index (ii) Hazard identification tools (iii) Preliminary hazard analysis. **(14 Marks)**

OR

14. (a) ExplainALARP triangle and give its significance in risk reduction.
    (b) Explain Dow Fire Index. Write the advantages and disadvantages of Dow Fire Index.
    (6 + 8 = 14 Marks)

Module III

15. Describe the HAZOP procedure and list the guide words. **(14 Marks)**

OR

16. (a) Explain Fault tree analysis used in quantifying Risk.
    (b) Construct an event tree for LPG release from a storage tank located in a LPGbottling plant. Assume frequency values for different situations. **(6 + 8 = 14 Marks)**

Module IV

17. (a) Explain the salient features of discharge rate models used for consequence modelling.
    (b) Explain the cause and consequence of BLEVE. **(7 + 7 = 14 Marks)**

OR

18. A gas with a molecular weight of 30 is used in a particular process. A source model study indicates that for a particular accident outcome 1.0 kg of gas will be released instantaneously. The release will occur at ground level. The plant fence line is 500 m away from the release. Determine: (i) the time required after the release for the center of the puff to reach the plant fence line. Assume a wind speed of 2 m/s, (ii) the maximum concentration of the gas reached outside the fence line. **(14 Marks)**

Module V

19. (a) Explain the significance of Probit functions in risk assessment with suitable example.
    (b) Explain individual risk and societal risk. **(7 + 7 = 14 Marks)**

OR

20. Give the importance of Emergency planning in process industries. Explain the detailed procedure and scope of such a study. **(14 Marks)**

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Syllabus

Module 1(9 Hrs.)

Hazard and risk – Hazard triangle, Types of hazards – Physical hazards, Chemical hazards and Biological hazards. Flammability hazards- Types of fire, Flammability limits, Flammability diagram. Toxic hazards and Industrial hygiene, Different types of doses- Effective dose, Toxic dose and Lethal dose, Evaluation of toxic hazards. Explosion hazards- Classification, Deflagration and Detonation. Reaction hazards and run-away reaction. Radiation hazards.

Module 2 (8 Hrs.)

Hazard Survey – Fire and Explosive index and Toxicity index, Mond index, Chemical exposure index and Inventory analysis. Major accident hazard units (MAH units). ALARP triangle. Major industrial accidents - Reasons, Bhopal and Flixborough disasters.

Module 3 (10 Hrs.)

Techniques for Hazard Identification - Process hazard analysis (PHA), Check lists, Safety audit, Hazard and Operability study (HAZOP), Layer of Protection analysis (LOPA), What-If analysis, Bow-tie analysis, Failure mode and effect analysis, Fault tree analysis and Event tree analysis.

Module 4 (9 Hrs.)

Consequence analysis - Consequence of chemical accidents, Procedure for consequence analysis- Selection of release incidents, Selection of source modelling, Selection of fire and explosion modelling- Pool modelling, modelling of BLEVE and TNT explosion modelling. Selection of Dispersion model.

Module 5 (9 Hrs.)

Risk Assessment – Probitequation,Probit equation for Fire, explosion and Toxic gas release, Risk indices, Individual risk- Risk contour, Average individual risk and Risk profile. Societal risk-F-N curves and Average Societal risk. Emergency planning- Onsite and Offsite emergency plan.

Text Books:

1. Daniel A. Crowl, Joseph F. Louvar, Chemical Process Safety-Fundamentals with Applications, Prentice Hall (2011).

2. Sam Mannan, Lees' Loss Prevention in the Process Industries: Hazard Identification, Assessment and Control, Vol 1-3-Butterworth-Heinemann (2004).

Reference Books

1. K. V. Raghavan and A A. Khan, "Methodologies in Hazard Identification and Risk Assessment", Manual by CLRI, 1990.
2. K S N Raju, Chemical Process Industry Safety, McGraw Hill Education (India) Private Limited.
3. V. C. Marshal, "Major Chemical Hazards", Ellis Horwood Ltd., Chichester, United Kingdom. 1987.
4. Geoff Wells, "Hazard Identification and Risk Assessment", I. ChE., John Ridley and John Channing, "Safety at Work", 6th Edition. Butterworth-Heinemann, 2003.
5. "A Guide to Hazard Operability Studies", Chemical Industry Safety and Health Council, 1977.
6. AIChE/CCPS, Guidelines for Hazard Evaluation Procedures, 2e, Centre for Chemical Process Safety, American Institute of Chemical Engineers, New York, 1992.
7. AIChE/CCPS, Guidelines for Chemical Process Quantitative Risk Analysis, 2e, Centre for Chemical Process Safety, American Institute of Chemical Engineers, New York, 2000.

Course Contents and Lecture Schedule:

No.	Details	No. of Lectures
1	**Module 1 - Hazard and risk (9 Hrs.)**	
1.1	Hazard triangle, Types of hazards – Physical hazards, Chemical hazards and Biological hazards.	2
1.2	Flammability hazards- Types of fire, Flammability limits, Flammability diagram.	2
1.3	Toxic hazards and Industrial hygiene,Different types of doses- Effective dose, Toxic dose and Lethal dose, Evaluation of toxic hazards.	2
1.4	Explosion hazards- Classification, Deflagration and Detonation.	1
1.5	Reaction hazards and run-away reaction. Radiation hazards.	2
2	**Module II - Hazard Survey (8 Hrs.)**	**8**
2.1	Fire and Explosive index and Toxicity index	2
2.2	Mond index, Chemical exposure index and Inventory analysis.	2
2.3	Major accident hazard units (MAH units). ALARP triangle.	2
2.4	Major industrial accidents - Reasons, Bhopal and Flixborough disasters.	2
3	**Module III - Techniques for Hazard Identification(11 Hrs.)**	
3.1	Preliminary hazard analysis (PHA), Check lists, Safety audit	2
3.2	Hazard and Operability study (HAZOP)	2
3.3	Layer of Protection analysis (LOPA)	1
3.4	What-If analysis, Bow-tie analysis, Failure mode and effect analysis	3
3.5	Fault tree analysis and Event tree analysis.	3
4	**Module IV - Consequence analysis (9 Hrs.)**	**9**

4.1	Consequence of chemical accidents, Procedure for consequence analysis	2
4.2	Selection of release incidents, Selection of source modelling	2
4.3	Selection of fire and explosion modelling- Pool modelling, modelling of BLEVE and TNT explosion modelling	3
4.4	Selection of Dispersion model	2
5	**Module V - Risk Assessment (8 Hrs.)**	**9**
5.1	Probit equation, Probit equation for Fire, explosion and Toxic gas release	2
5.2	Risk indices, Individual risk- Risk contour, Average individual risk and Risk profile	2
5.3	Societal risk-F-N curves and Average Societal risk	2
5.4	Emergency planning- Onsite and Offsite emergency plan	2

CHT384	PETROCHEMICAL TECHNOLOGY	CATEGORY	L	T	P	CREDIT
		VAC	3	1	0	4

Preamble: This course introduced with an objective to develop the knowledge to learn scientific and technologicalprinciples of organic synthesis and related unit processes. It provides an understanding on the role of Petrochemical engineer in unit processes used for organicsynthesis and polymerization processes. Students will acquire the ability to understand the unit processes in organic synthesis, varietyof petrochemical feedstock and products, process technologies for Fibers, Elastomers and resins and gets familiar with major polymerization processes on industrial scale

Prerequisite: Nil

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

CO 1	List various petrochemical feed stocks and their preparation and utilization.
CO 2	Summarize the production of various petrochemicals based on Ethylene, Propylene and Butadiene.
CO 3	Identify the production, separation and utilization of aromatics in the petrochemical industries.
CO 4	Outline the process technologies for Fibers, Elastomers and resins and also gets familiar with major polymerization processes on industrial scale.
CO 5	Explain the various process for the production of synthetic detergents.

Mapping of course outcomes with program outcomes

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

Assessment Pattern

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

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

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

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

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Compare the process of synthesis gas production by steam reforming of naphtha and natural gas
2. Demonstrate the difference between LNG, CNG, and NGL
3. Outline the production of methanol from synthesis gas

Course Outcome 2 (CO2)

1. Explain the production of acrylonitrile and acrylic acid
2. Explain the steps involved in the production of ethanol amine from ethylene

Course Outcome 3(CO3):

1. Briefly explain alkylation of benzene
2. Describe the production of benzene, toluene, and xylene from BTX aromatics by distillation.

Course Outcome 4 (CO4):

1. Describe the production of SBR, PBR and Butyl rubber
2. Demonstrate the production of Nylon 6 and Nylon 6,6
3. Explain the production of Phenol Formaldehyde resins

Course Outcome 5 (CO5):

1. Describe the sulphonation of LAB for production of Synthetic Detergents

Model Question paper
QP CODE: PAGES: 3

Reg No: ______________

Name: ______________

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

Course Code: CHT 384
Max. Marks: 100 Duration: 3 Hours

Petrochemical Technology
(2019-Scheme)

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

1 Demonstrate the difference between LNG, CNG, and NGL

2 List the various chemicals from synthesis gas

3 List six major petrochemical products and their applications

4 Explain the steps involved in the production of ethanol amine from ethylene

5 Write the various uses of xylene

6 Briefly explain alkylation of benzene

7 Write basic difference between LDPE, LLDPE, and HDPE

8 Explain the major steps involved in the production of PVC

9 What are the basic difference between nylon 6 and nylon 6,6?

10 What is LAB and its application?

PART B

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

Module –I

11	a	Compare the process of synthesis gas production by steam reforming of naphtha and natural gas	8
11	b	Outline the production of methanol from synthesis gas	6
12	a	Explain the natural gas processing	14

Module – II

13		Describe the production of ethylene, propylene, and butadiene by naphtha cracking.	14
14		Explain the production of acrylonitrile and acrylic acid	14

Module – III

15	a	Describe the production of benzene, toluene, and xylene from BTX aromatics by distillation.	9
15	b	Explain the production of Phthalic Anhydride	5
16		Describe the production of Styrene, Cumene and Phenol	14

Module – IV

17	a	Describe the production of PVC and Polystyrene	9
17	b	What are the application of LDPE, LLDPE and HDPE?	5
18		Describe the production of SBR, PBR and Butyl rubber	14

Module – V

19		Explain the production of Nylon 6 and Nylon 6,6	14
20	a	Explain the production of Phenol Formaldehyde resins	7
20	b	Describe the sulphonation of LAB for production of Synthetic Detergents	7

Syllabus

Module 1 (10 Hrs.)

Petrochemical Industries & their feed stocks, Natural Gas processing, General idea of LNG, CNG, NGL, LPG and their generation, Production and Utilization of Synthesis gas, Process of Synthesis gas production by steam reforming of Natural Gas, Process of Synthesis gas production by steam reforming of Naphtha, partial oxidation of Fuel Oil, Production of Methanol from Synthesis gas, Chemicals from Synthesis gas by Oxosynthesis, Production of liquid fuels from Synthesis gas by Fischer – Tropsch process

Module 2 (10 Hrs.)

Major Petrochemical products and their applications. First, Second and Third generation petrochemical products, Production of Ethylene, Propylene,andButadiene by Naphtha/Gas cracking, Petrochemicals based on Ethylene, Propylene and Butadiene: Like VCM, VAM,Ethylene Oxide, Ethylene Glycol,Ethanol Amines from Ethylene, Acrylonitile, Isopropanol, Propylene oxide,Glycerine, Acrylic acid,Acrolein from Propylene, Production of Butadiene

Module 3 (8 Hrs.)

Production, Separation and Utilization of Aromatics: - Catalytic Reformation of Naphtha and production of Xylenes, Separation of Xylenes, Isomerization of Meta xylene, Pyrolysis Gazoline hydrogenation and separation of BTX aromatics, Production of Benzene, Toluene, Xylenes from BTX aromatics by distillation, Production of Benzene from Toluene, Uses of xylenes, Alkylation of Benzene, Production of Styrene, Cumene and Phenol, Production of Phthalic Anhydride.

Module 4 (9 Hrs.)

Plastomers, Elastomers and Synthetic fibres: Various methods of polymerization and their mechanisms, Production processes of LDPE, LLDPE and HDPE, Basic difference among the three and their applications, Production of PVC and Polystyrene, Production of Polypropylene, Production of SBR, PBR and Butyl rubber, Production of ABS plastics

Module 5 (8 Hrs.)

Polytetrafluoroethylene, polycarbonate, Purified teraphthalicacid (PTA), Ethylene Glycol, Production of Polyamide (Nylon 6 and Nylon 6,6), Polyester and Acrylic fibres, Production of Phenol Formaldehyde resins, Synthetic Detergents: Classification of detergents, Production of Linear Alkyl Benzene (LAB) from Superior Kerosene and Benzene, Sulphonation of LAB for production of Synthetic Detergents. Additives for synthetic detergents.Hard and soft detergents.

Text Books

1. A Text on Petrochemicals: B.K.B. Rao, Khanna Pub.
1. Petrochemical processes: Chauvel ,Gulf Publishing
2. Introduction to Petrochemicals, SukumarMaity. Oxford and IBH Publishing Co.

Reference Books

1. Advanced Petrochemicals: Dr. G. N. Sarkar, Khanna Publishers
2. The Petroleum chemicals Industry: R. F. Goldstein and A. L. Waddams

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Module 1: (10 Hrs.)**	
1.1	Petrochemical Industries & their feed stocks	1
1.2	Natural Gas processing, General idea of LNG, CNG, NGL, LPG and their generation	2
1.3	Production and Utilization of Synthesis gas, Process of Synthesis gas production by steam reformingof Natural Gas and Naphtha, partial oxidation of Fuel Oil	3

1.4	Production of Methanol from Synthesis gas	1
1.5	Chemicals from Synthesis gas by Oxosynthesis	1
1.6	Production of liquid fuels from Synthesis gas by Fischer – Tropschprocess	2
2	**Module 2: (10 Hrs.)**	
2.1	Major Petrochemical products and their applications. First, Second and Third generation petrochemical products.	1
2.2	Production of Ethylene, Propylene,andButadiene by Naphtha/Gas cracking	1
2.3	Petrochemicals based on Ethylene,Propylene and Butadiene: Like VCM, VAM,Ethylene Oxide, Ethylene Glycol,Ethanol Amines from Ethylene.	4
2.4	Acrylonitile, Isopropanol, Propylene oxide,Glycerine, Acrylic acid,Acrolein from Propylene.	3
2.5	Production of Butadiene	1
3	**Module 3: (8 Hrs.)**	
3.1	Production, Separation and Utilization of Aromatics: - Catalytic Reformation of Naphtha and production of Xylenes, Separation of Xylenes, Isomerization of Meta xylene.	3
3.2	Pyrolysis Gazoline hydrogenation and separation of BTX aromatics	1
3.3	Production of Benzene, Toluene, Xylenes from BTX aromatics by distillation	1
3.4	Production of Benzene from Toluene, Uses of xylenes	1
3.5	Alkylation of Benzene. Production of Styrene, Cumene, Phenol, and Phthalic Anhydride	2
4	**Module 4: (9 Hrs.)**	
4.1	Plastomers, Elastomers and Synthetic fibres: Various methods of polymerization and their mechanisms.	2
4.2	Production processes of LDPE, LLDPE and HDPE, Basic difference among the three and their applications	3
4.3	Production of PVC, Polystyrene, Polypropylene, ABS plastics, SBR, PBR and Butyl rubber	4
5	**Module 5: (8 Hrs.)**	
5.1	Polytetrafluoroethylene, polycarbonate, Purified teraphthalicacid (PTA), Ethylene Glycol.	2
5.2	Production of Polyamide (Nylon 6 and Nylon 6,6), Polyester and Acrylic fibres, Production of Phenol Formaldehyde resins.	2
5.3	Synthetic Detergents: Classification of detergents, Production of Linear Alkyl Benzene (LAB) from Superior Kerosene and Benzene, Sulphonation of LAB for production of Synthetic Detergents. Additives for synthetic detergents. Hard and soft detergents.	4

CHT386	NANOMATERIALS AND NANOTECHNOLOGY	CATEGORY	L	T	P	CREDIT
		VAC	3	1	0	4

Preamble: Nanotechnology has emerged as an important and exciting area in science and engineering. It provides promises in much technological advancement with wide range of application fields. The course gives a basic introduction to chemical and physical principles in the synthesis of nanomaterials. It also covers different methods for synthesis, properties, applications and characterization of nanoscale materials.

Prerequisite: Basic knowledge of material science.

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

CO 1	Understand the concepts of nanotechnology and apply the basic principles of Physics and Chemistry in Nanotechnology
CO 2	Explain synthesis, properties and applications of nanomaterials and nanocomposites
CO 3	Apply nanotechnology in biological fields and acquire the knowledge about drug delivery, biosensors, nanomedicine and therapeutic applications
CO 4	Develop understanding about various characterisation techniques applied to nanomaterials
CO 5	Understand the applications of nanotechnology in energy sector, catalysis and electronics

Mapping of course outcomes with program outcomes

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

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	10
Understand	20	20	20
Apply	20	20	70
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

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

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

Course Level Assessment Questions

Course Outcome 1 (CO1): Understand the concepts of nanotechnology and apply the basic principles of Physics and Chemistry in Nanotechnology

1. Write a note on pioneers who contributed for the propagation of the ideas of nanotechnology.
2. Describe the classification of nanomaterials.
3. Briefly describe the ionic properties of nanomaterials

Course Outcome 2 (CO2): Explain synthesis, properties and applications of nanomaterials and nanocomposites

1. Distinguish between top down and bottom up approach in nanomaterial synthesis
2. Describe any one method for the synthesis of nanogold. Mention its applications
3. What are the applications of carbon nanotubes?
4. Compare metal matrix and polymer matrix nanocomposites.

Course Outcome 3(CO3): Apply nanotechnology in biological fields and acquire the knowledge about drug delivery, biosensors, nanomedicine and therapeutic applications

1. Explain the application of nanotechnology in drug delivery.
2. What are biosensors?
3. Discuss on the future of Bio nanotechnology.

Course Outcome 4 (CO4): Develop understanding about various characterisation techniques applied to nanomaterials

1. Explain the principle and operation of XRD.

2. Compare and contrast SEM and TEM

3. Discuss on the thermal analytical techniques for nanomaterials

Course Outcome 5 (CO5): Understand the applications of nanotechnology in energy sector, catalysis and electronics

1. What are the application of nanomaterials in catalysis?
2. Describe Nano Electro Mechanical Systems and their applications.
3. Discuss on the application of nanotechnology in energy conversion.

Model Question Paper

QP CODE: PAGES:2

Reg No:_______________
Name :_______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
SIXTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR
Course Code: CHT 386

Max. Marks: 100
Duration: 3 Hours

NANOMATERIALS AND NANOTECHNOLOGY
(2019-Scheme)
PART A

(Answer all questions, each question carries 3 marks)

1. Explain electromagnetic spectrum

2. What is quantum confinement effect?

3. Distinguish between top down and bottom up approach in nanomaterial synthesis
4. Write down the various steps in CVD process.

5. What is the significance of nanofillers? Give examples.

6. What are biosensors?

7. What is the interpretation of output from UV-visible spectroscopy?

8. Explain the principle of thermogravimetric analysis

9. Give examples of nanomaterials used in catalysis.

10. What are the applications of nanolithography?

PART B

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

Module -I

11. Write a note on pioneers who contributed for the propagation of the ideas of nanotechnology.

12. (a) Describe the classification of nanomaterials.

(b) How surface area and aspect ratio influence the change in properties of nanomaterials?

Module -II

13. What is CVD? Describe the classification of CVD processes. What are the various steps involved in a CVD process?

14. Describe the synthesis, properties and applications of carbon nano tubes.

Module -III

15. Write a note on polymer nanocomposites. Explain the significance of nanofillers citing examples.

16. What is targeted drug delivery? What are the applications of nanomaterials in cancer treatment?

Module -IV

17. Describe the principle and operation of SEM using a ray diagram

18. Discuss on the various characterisation techniques to conduct thermal degradation studies.

Module -V

19. Explain the application of nanomaterials in energy conversion and storage.

20. Describe photolithography using a neat diagram. (14x5 =70)

Syllabus

Module 1 (Introduction and general properties) (9 Hrs.)

Introduction to Nanotechnology - History of nanotechnology, Pioneers in the field of nanotechnology. Classification of nano-materials: Zero, one, two and three dimensional nano-structured materials. Electromagnetic spectrum, particle size and its significance.
Physics of nanomaterials - Size effect on thermal, electrical, electronic, mechanical, optical and magnetic properties of nanomaterials- surface area and aspect ratio- band gap energy- quantum confinement effect.
Chemistry of nanomaterials - Ionic properties of nanomaterials, electronic phenomenon in nanostructures.

Module 2 (Synthesis methods) (10 Hrs.)

Synthesis methods - top down and bottom up approach. Top down approach – size reduction techniques like milling and machining.
Bottom up approach - Sol-gel methods, Chemical vapour deposition, Physical Vapour Deposition, Wet chemical synthesis, Laser ablation methods
Synthesis, properties and applications of nanomaterials like gold, silver and different types of nano-oxides like Al_2O_3, TiO_2, 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) (8 Hrs.)

Nanocomposites - Matrix materials- Basics of Metal matrix, Ceramic Matrix and Polymer Matrix nanocomposites - Nano-reinforcements, nanofillers- nanoclays. Introduction to bionanotechnology (fundamental concepts only) - Nanomedicine, Drug delivery, Therapeutic applications Applications of biosensors, Future of Bionanotechnology.

Module 4 (Characterisation techniques) (10 Hrs.)

Characterisation techniques - Scanning Electron Microscopy (SEM) - Energy Dispersive X-ray Spectroscopy (EDS) - Transmission Electron Microscopy (TEM) - Atomic Force Microscopy (AFM), Scanning Probe Microscopy (SPM) - Scanning Tunneling Microscopy (STM). UV-visible spectroscopy, Raman spectroscopy, Nuclear Magnetic Resonance Spectroscopy (NMR), Fourier Transform Infrared Spectroscopy (FTIR). X-Ray Diffraction (XRD), Dynamic Light Scattering (DLS)
Thermogravimetric analysis (TGA), Differential Thermal Analysis (DTA), Differential Scanning Calorimetry (DSC)

Module 5 (Applications in energy, catalysis and electronics) (8 Hrs.)

Applications (fundamental concepts only) -: Nanoscale advances in energy and catalysis - Nanotechnology for sustainable energy, nanotechnology enabled renewable energy technologies. Application of nanomaterials in catalysis.

Nanoelectronics - Introduction to Micro Electro Mechanical Systems (MEMS), Nano Electro Mechanical Systems (NEMS)
Nanomanipulation – STM based atomic manipulations, Nanolithography, softlithography, Scanning Probe Lithography, photolithography, E-beam Lithography, Focused ion beam lithography, Dip-pen Lithography

Text Books

1. Joel I. Gersten, ―The Physics and Chemistry of Materials, Wiley, 2001 2. G. Cao, Nanostructures & Nanomaterials: Synthesis, Properties & Applications, Imperial College Press, 2004.
2. S Zhang, L. Li and Ashok Kumar, Materials Characterization Techniques, CRC Press (2008).
3. T. Pradeep, Nano: The Essentials, McGraw-Hill (India) Pvt Limited, 2008.
4. Nanocomposite science and technology, Pulikel M. Ajayan, Wiley-VCH 2005
5. C. M. Niemeyer, C. A. Mirkin, ―Nanobiotechnology: Concepts, Applications and Perspectives, Wiley – VCH, (2004)
6. J. Twidell and T. Weir, Renewable Energy Resources, E & F N Spon Ltd, London, (1986)
7. Nanotechnology in Catalysis Volumes 1 and 2, Bing Zhou, Sophie Hermans, Gabor A. Somorjai , Springer Science & Business Media, 05-Sep-2007
8. W.R.Fahrner, Nanotechnology and Nanoelectronics–Materials, Devices, Measurement Techniques, Springer-Verlag Berlin, Germany (2006).

Reference Books

1. K.W. Kolasinski, ―Surface Science: Foundations of Catalysis and Nanoscience, Wiley, 2002.
2. S. Edelstein and R. C. Cammarata, ―Nanomaterials: Synthesis, Properties and Applications, Institute of Physics Pub., 1998.
3. S.Yang and P.Shen: ―Physics and Chemistry of Nanostructured Materials,Taylor & Francis, 2000.
4. Z L Wang (Ed.), Characterization of Nanophase materials, Willet-VCH (2000).
5. Guo, Jinghua (Ed.), X-rays in Nanoscience - Spectroscopy, Spectromicroscopy, and Scattering Techniques, John Wiley &Sons (2010).
6. Handbook of Nanoscience, Engineering and Technology, Kluwer publishers, 2002.
7. David S Goodsell, "Bionanotechnology, John Wiley & Sons, (2004).
8. Zheng Cui, Nanofabrication, Principles, Capabilities and Limits, Springer Science + business media, New York (2008).

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Introduction and general properties (9 Hrs.)**	
1.1	Introduction to Nanotechnology - History of nanotechnology, Pioneers in the field of nanotechnology.	2
1.2	Classification of nano-materials: Zero, one, two and three dimensional nano-structured materials.	1
1.3	Electromagnetic spectrum, particle size and its significance.	1
1.4	Physics of nanomaterials - Size effect on thermal, electrical, electronic, mechanical, optical and magnetic properties of nanomaterials- surface area and aspect ratio- band gap energy- quantum confinement size effect.	3
1.5	Chemistry of nanomaterials - Ionic properties of nanomaterials, electronic phenomenon in nanostructures.	2
2	**Synthesis methods (10 Hrs.)**	
2.1	Top down approach – size reduction techniques like milling and machining.	1
2.2	Bottom up approach - Sol-gel methods, Chemical vapour deposition, Physical Vapour Deposition, Wet chemical synthesis, Laser ablation methods	3
2.3	Synthesis, properties and applications of nanomaterials like gold, silver and different types of nano-oxides like Al2O3, TiO2, ZnO and SiO_2	2
2.4	Special nano-materials - synthesis, properties and applications – fullerenes, graphene, graphite	2
2.5	synthesis, properties and applications of carbon nano-tubes, nano wires, nano rods, nanofluids, nanoclusters	2
3	Nanocomposites and Bionanotechnology **(8 Hrs.)**	
3.1	Matrix materials- Basics of Metal matrix, Ceramic Matrix nanocomposites	2
3.2	Polymer Matrix nanocomposites - Nano-reinforcements, nanofillers- nanoclays	2
3.3	Introduction to bionanotechnology- Nanomedicine, Drug delivery, Therapeutic applications	2
3.4	Applications of biosensors, Future of Bionanotechnology	2
4	**Characterisation techniques (10 Hrs.)**	
4.1	Scanning Electron Microscopy (SEM) - Energy Dispersive X-ray Spectroscopy (EDS) - Transmission Electron Microscopy (TEM) - Atomic Force Microscopy (AFM), Scanning Probe Microscopy (SPM) - Scanning Tunneling Microscopy (STM)	3
4.2	UV-visible spectroscopy, Raman spectroscopy, Nuclear Magnetic	3

	Resonance Spectroscopy (NMR), Fourier Transform Infrared Spectroscopy (FTIR)	
4.3	X-Ray Diffraction (XRD), Dynamic Light Scattering (DLS)	1
4.4	Thermogravimetric analysis (TGA), Differential Thermal Analysis (DTA), Differential Scanning Calorimetry (DSC)	3
5	**Applications in energy, catalysis and electronics (8 Hrs.)**	
5.1	Applications: Nanotechnology for sustainable energy, nanotechnology enabled renewable energy technologies	2
5.2	Application of nanomaterials in catalysis.	2
5.3	Nanoelectronics - Introduction to Micro Electro Mechanical Systems (MEMS), Nano Electro Mechanical Systems (NEMS)	1
5.4	Nanomanipulation – STM based atomic manipulations, Nanolithography, softlithography, Scanning Probe Lithography, photolithography, E-beam Lithography, Focused ion beam lithography, Dip-pen Lithography	3

SEMESTER VI

HONOURS

CHT394	CHEMICAL REACTION ENGINEERING II	CATEGORY	L	T	P	CREDIT
		VAC	3	1	0	4

Preamble: The objective of this course is to impart and to continue the rigorous study of reaction engineering. In this course, particular emphasis will be given to chemical kinetics, review of elements of reaction kinetics, rate processes in homogeneous and heterogeneous reacting systems, design of ideal and non-ideal reactors, models of non-ideal flow, design of fluid-solid non-catalytic reactions and reactor design.

Prerequisite: CHT 305 Chemical Reaction Engineering.

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

CO 1	Design of ideal reactors for homogeneous systems.
CO 2	Design of chemical reactors for homogeneous systems incorporating non isothermal and non-ideality in the reaction condition.
CO 3	Development of design equations for ideal reactor for heterogeneous systems.
CO 4	Analyse the effect of diffusion process and reaction kinetics in porous catalyst system.
CO 5	Design chemical reactors for fluid particle non catalytic reactions.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3		3									
CO 2	3		3									
CO 3	3		3									
CO 4		3	2									
CO 5	3		3									

Assessment Pattern

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination**
	1	**2**	
Remember	10	10	10
Understand	20	20	20
Apply	20	20	70
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

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

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

Course Level Assessment Questions

Course Outcome 1 (CO1): Design of ideal reactors for homogeneous systems.

1. Derive the performance equation for an ideal batch reactor.
2. Explain integral and differential method of analysing batch reactor data.
3. Compare the performance of plug flow reactors connected in series and parallel.

Course Outcome 2 (CO2): Design of chemical reactors for homogeneous systems incorporating non isothermal and non-ideality in the reaction condition.

1. Derive the expression for conversion for a non isothermal adiabatic reaction starting from the energy balance equation.
2. Explain segregation model in non ideal reactors.
3. Define the terms (i) RTD (ii) Dispersion number and (iii) Variance.

Course Outcome 3(CO3): Development of design equations for ideal reactor for heterogeneous systems.

1. Derive the performance equation of PFR containing porous catalyst particles.
2. Explain the Langmuir- Hinshelwood surface reaction model.
3. Explain the steps involved in a heterogeneous catalytic reaction.

Course Outcome 4 (CO4): Analyse the effect of diffusion process and reaction kinetics in porous catalyst system.

1. Obtain Thiele modulus from the derivation describing diffusion and reaction

   for $A \rightarrow B$.

2. Define the terms effective diffusivity and tortousity.

3. Differentiate internal effectiveness factor and overall effectiveness factor.

Course Outcome 5 (CO5): Design chemical reactors for fluid particle non catalytic reactions.

1. Explain shrinking core model for particles of unchanging size.

2. A batch of solids of uniform size is treated by gas in a uniform environment. Solid is converted to give a non flaking product according to SCM. The conversion is about 87.5% in a reaction time of 1 hr and conversion is complete in 2 hrs. Determine the rate controlling mechanism.

3. Derive the relationship between time and conversion for solid fluid non catalytic reaction, without change in particle size in which gas film diffusion controls the rate.

Model Question paper

QP CODE: **PAGES: 4**

Reg No:______________

Name :______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
SIXTH SEMESTER B.TECH DEGREE EXAMINATION,
MONTH & YEAR
Course Code: CHT 394
ADVANCED CHEMICAL REACTION ENGINEERING

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

(2019-Scheme)

PART A

(Answer all questions, each question carries 3 marks)

1. Define an autocatalytic reaction with example.

2. Define space time and space velocity.

3. What are the causes of non ideality in reactors?

4. Differentiate microfluid and macrofluid.

5. Differentiate physisorption and chemisorption.

6. What are the different types of heterogeneous reactions?

7. Define (i) internal effectiveness factor and (ii) overall effectiveness factor.

8. Give the significance of thiele modulus in diffusion and reaction of porous catalyst pellets.

9. Differentiate SCM and PCM.

10. What are the different types of fluid- solid non catalytic reactions?

PART B

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

Module I

11. a. Obtain the conversion for first order reversible reaction A ↔ R which occurs in a batch reactor. 8 marks

b. A PFR of 2 m^3 processes an aqueous feed (100 L/minutes) containing reactant A (C_{A0}=100 mmols/ L). This reaction is reversible A↔ R represented by $-r_A=0.04 min^{-1} C_A - 0.01 min^{-1} C_R$. First find the equilibrium conversion and then find actual conversion of A in the reactor. 6 marks

12. a. Show that the performance of N equal sized mixed flow reactors in series is equal to a plug flow reactor. Assume first order reaction. 8 marks

b. Compare the performance of plug flow reactors connected in series and parallel.

6 marks

Module II

13. a. Discuss on multiple steady state in an isothermal CSTR. 8 marks

b. From pulse input in to a vessel we obtain the following output signal. Use Tank in series model. Determine the number of tanks.

t, min	1	3	5	7	9	11	13	15
C pulse, g/l	0	0	10	10	10	10	0	0

6 marks

14. a. A Sample of tracer is injected as a pulse to a reactor and following C pulse versus time data is obtained. Tabulate E (t) and F (t) values.

t(min)	0	1	2	3	4	5	6	7	8	9	10	12	14
C (g/m^3)	0	1	5	8	10	8	6	4	3	2.2	1.5	0.6	0

6 marks

b. Explain tank in series model. 8 marks

Module III

15. a. For the reaction $A + B \leftrightarrow C$, the mechanism is given by

$A + S \leftrightarrow A.S$ *Adsorption*

$B + S \leftrightarrow B.S$

$A.S + B.S \leftrightarrow C.S + S$ *Surface Reaction*

$C.S \leftrightarrow C + S$ *Desorption*

Develop the overall rate equation assuming (a) adsorption of A as rate controlling (b) Surface reaction as rate controlling. 9 marks

b. Derive the performance equation of MFR containing porous catalyst particles.

5 marks

16. a. Determine the amount of catalyst needed in a packed bed reactor with a very large recycle rate (assume mixed flow) for 35 % conversion of A to R for a feed rate of 2000mol/hr of pure A at 3.2 atm and 117 ^{0} C. For the reaction at this temperature, $A \rightarrow 4R$, $-r_A' = 96\, C_A$, mol/Kg catalyst.hr. 5 marks

b. Develop the rate equation for decomposition of Cumene to form Benzene and Propylene in gas phase.

$C+S \leftrightarrow C.S$ Adsorption of Cumene

$C.S \leftrightarrow B.S+P$ (g) Surface reaction to form Benzene and Propylene in gas phase

$B.S \leftrightarrow B+S$ Desorption of Benzene

Develop the overall rate equation assuming (a) Adsorption is controlling. (b) Surface reaction is controlling. 9 marks

Module IV

17. a. Explain (i) Weisz - Prater criterion for internal diffusion and (ii) Mears criterion for external diffusion. 6 marks

b. Obtain Thiele modulus from the derivation describing diffusion and reaction for $A \rightarrow B$. 8 marks

18. a. Explain the terms (i) effective diffusivity (ii) tortuosity and (iii) constriction factor.

6 marks

b. Derive the expressions for internal effectiveness factor for diffusion and reaction in spherical catalyst pellet 8 marks

Module V

19. a. Calculate the time required for complete burning of graphite (Size R_0 =5mm, density =2.28g/cc) in an 8% oxygen stream at 900 ^{0}C and 1 atm. For high gas velocity assume that film diffusion does not offer any resistance to transfer and reaction. Rate constant k″=20 cm/s. 7 marks

b. Explain shrinking core model for particles of changing size. Derive the relationship between time, shrinking particle size and conversion for reaction in which gas film diffusion controls the rate 7 marks

20. a. With a neat sketch of the concentration profiles, compare shrinking core model with progressive conversion model. 6 marks

b. Spherical solid particles containing B is roasted at constant temperature in an oven by a gas A. The solids are converted to give a non flaking solid product according to the shrinking core model. If diffusion through the ash layer controls, derive an expression for the time required for the progression of reaction, time required for complete conversion and fractional conversion. 8 marks

Syllabus

Module 1 (10 Hrs.)

Chemical Reaction Engineering overview- Reaction Kinetics- constant volume and variable volume batch reactor-Ideal reactors design equations- Ideal batch rectors-Steady state mixed flow reactors- steady state plug flow reactors- design of Single and multiple reactions - multiple reactor systems.

Module 2 (8 Hrs.)

Non isothermal effect into the reactor design- Temperature and pressure effects- Heat effects: adiabatic operations and non-adiabatic operations Multiple Steady States in CSTR. Basics of non-ideal flow- Models of non- ideal flow- zero parameter model-segregation model-One parameter model Compartment models, axial dispersion model, tanks-in-series model- Convection model for laminar flow- Earliness of mixing, segregation and RTD.

Module 3 (10 Hrs.)

Heterogeneous processes. Global rates of reaction. Types of Heterogeneous reactions - Catalysis. General characteristics of catalysis. Physical adsorption and chemisorption. steps in a catalytic reaction, adsorption equilibrium constant, desorption, surface reaction, synthesizing rate law, rate limiting step-Langmuir- Hinshelwood approach. Development of design equations for ideal mixed batch reactor, plug flow tubular reactor and perfectly mixed continuous stirred tank reactor for heterogeneous systems. Heterogeneous data analysis for reactor design.

Module 4 (8 Hrs.)

Diffusion and reaction in porous catalysts- effective diffusivity, tortuosity-modelling of diffusion with reaction on a spherical catalysts. Thiele Modulus, internal effectiveness factor, Overall effectiveness factor. Estimation of diffusion and reaction limited regimes - Weisz - Prater criterion for internal diffusion, Mears criterion for external diffusion- Mass transfer and reaction in a packed bed.

Module 5 (9 Hrs.)

Fluid Particle Non catalytic Reactions kinetics-Selection of a model-Unreacted core model for spherical particles of unchanging size, model development for diffusion through gas film, ash layer, and chemical reaction controls. Rate of reaction for shrinking spherical particles - chemical reaction controls, diffusion controls, Determination of the rate-controlling step- Fluid Particle reactor design

Text Books

1. Levenspiel Octave , “Chemical Reaction Engineering”, John Wiley & Sons, Third Edition,.
2. H Scott Fogler, “Elements of Chemical Reaction Engineering”, Prentice Hall of India, Fifth Edition.
3. Smith J.M, “Chemical Engineering Kinetics,” McGraw Hill.

Reference Books

1. James J Carberry, “Chemical &Catalytic Reaction Engineering”, Mc Graw Hill.
2. K.G Denbigh& J.C.R Turner, “Chemical Reactor Theory- An Introduction”, Cambridge University Press.
3. Lanny D Schmidt, “The Engineering of Chemical Reactions”, Oxford University Press.
4. Ronald W. Missen, Charles A. Mims, Bradley A. Saville, „Introduction to Chemical Reaction Engineering and Kinetics‟, John Wiley & Sons
5. Hill C.G., An Introduction to Chemical Engineering Kinetics & Reactor Design, John Wiley

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Module I (10 Hrs.)**	
1.1	Chemical Reaction Engineering overview	1
1.2	Reaction Kinetics- constant volume rectors	2
1.3	Reaction Kinetics- variable volume rectors	1
1.4	Ideal reactors design equations- Ideal batch rector	1
1.5	Ideal reactors design equations -Steady state mixed flow reactors	1
1.6	Ideal reactors design equations- steady state plug flow reactors	1
1.7	Design of Single and multiple reactions -multiple reactor systems.	3
2	**Module II (8 Hrs.)**	
2.1	Non isothermal effect into the reactor design- Temperature and pressure effects	1
2.2	Heat effects: adiabatic operations and non-adiabatic operations Multiple Steady States in CSTR.	1
2.3	Basics of non-ideal flow	1
2.4	Models of non-ideal flow- zero parameter model Segregation model-One parameter model	1
2.5	Compartment model and axial dispersion model	2
2.6	Tanks-in-series model and Convection model for laminar flow	1
2.7	Earliness of mixing, segregation and RTD	1
3	**Module III (10 Hrs.)**	
3.1	Heterogeneous processes. Global rates of reaction. Types of Heterogeneous reactions	1
3.2	Catalysis. General characteristics of catalysis. Physical adsorption and chemisorption. steps in a catalytic reaction	2
3.3	Adsorption equilibrium constant, desorption, surface reaction,	2
3.4	Synthesizing rate law, rate limiting step-Langmuir- Hinshelwood approach.	2
3.5	Development of design equations for ideal mixed batch reactor, plug flow tubular reactor and perfectly mixed continuous stirred tank reactor for heterogeneous systems.	2
3.6	Heterogeneous data analysis for reactor design.	1
4	**Module IV (8 Hrs.)**	
4.1	Diffusion and reaction in porous catalysts- effective diffusivity, tortuosity	1
4.2	Modelling of diffusion with reaction on a spherical catalysts.	1
4.3	Thiele Modulus, internal effectiveness factor, Overall	2

	effectiveness factor.	
4.4	Estimation of diffusion and reaction limited regimes - Weisz - Prater criterion for internal diffusion	2
4.5	Mears criterion for external diffusion- Mass transfer and reaction in a packed bed.	2
5	**Module V (9 Hrs.)**	
5.1	Fluid Particle Non catalytic Reactions kinetics	1
5.2	Selection of a model -Unreacted core model for spherical particles of unchanging size	2
5.3	Model development for diffusion through gas film, ash layer, and chemical reaction controls.	2
5.4	Rate of reaction for shrinking spherical particles - chemical reaction controls, diffusion controls,	1
5.5	Determination of the rate-controlling step.	1
5.6	Fluid Particle reactor design	2

CHT396	ADVANCED WASTE WATER TREATMENT TECHNIQUES	CATEGORY	L	T	P	CREDIT
		VAC	3	1	0	4

Preamble: This subject aims to give knowledge to the students regarding advanced wastewater treatment technologies. It details primary, secondary, tertiary and advanced methods of treatments of waste water and the sludge disposal techniques. Also, it covers the methodology for treating the effluents from different industries and helps to understand the regulatory standards of treated effluents from various industries and the Legislations.

Prerequisite : Knowledge of physical, chemical and biological treatment of wastewater

Course Outcomes:

After the completion of the course the student will be able to

CO 1	Identify the Environmental problems and the regulatory requirements for treatment and disposal of waste water.
CO 2	Analyse conventional biological treatment methods
CO 3	Apply advanced technologies in Wastewater treatment
CO 4	Explain different types of electrochemical treatment options for wastewater treatment.
CO5	Select treatment options for different types of industrial effluent.

Mapping of course outcomes with program outcomes

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

Assessment Pattern

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination**
	1	**2**	
Remember	10	10	10
Understand	20	20	20
Apply	20	20	70
Analyse			

Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

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

End Semester Examination Pattern:

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

Course Level Assessment Questions

Course Outcome 1 (CO1): Identify the Environmental problems and the regulatory requirements for treatment and disposal of waste water.

1. Explain the Characteristics of Wastewater from different sources.
2. List the environmental consequences of wastewater discharge
3. List the Regulation or Legislation in Water Pollution.

Course Outcome 2 (CO2): Analyse conventional biological treatment methods

1. Explain the microorganism involved biological processes.
2. Derive basic equation for the activated sludge process.
3. Discuss about the nitrogen removal processes in wastewater treatment

Course Outcome 3(CO3): Apply advanced technologies in wastewater treatment

1. Describe the Filtration and membrane separation techniques in wastewater treatment.
2. Explain the ion exchange processes.
3. Discuss about various types of membrane seperation processes used in wastewater treatment.

Course Outcome 4 (CO4): Explain different types of electrochemical treatment options for wastewater treatment.

1. List out the various reactor configurations used in electrocoagulation.
2. Explain the functioning of electro floatation process.
3. Discuss the theory of advanced oxidation.

Course Outcome 5 (CO 5): Select treatment options for different types of industrial effluent..

1. Propose a treatment scheme for treating sugar industry effluent.
2. Explain the methods adopted to remove oil and grease from wastewater.
3. Propose a treatment scheme to treat tannery industry effluent.

MODEL QUESTION PAPER

PAGES:

Reg No:______________ **Name :______________**

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SIXTH SEMESTER B. TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: CHT 396

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

ADVANCED WASTE WATER TREATMENT TECHNIQUES

PART A

(Answer all questions, Each carry 3 marks)

1. List the environmental legislations prevails in India?
2. Write the classification of wastewater treatment methods.
3. Distinguish the neutralisation and equalisation processes.
4. Briefly describe the oxygen requirement in aerobic process
5. Write the principle of reverse osmosis.
6. List out the different types of membranes used in wastewater treatment
7. Discuss about the commonly used electode material in electrochemical treatment of wastewater?
8. Explain the working of solar photo catalytic treatment systems?
9. Explain the common Operational problems encountered in treatment plants
10. Write Sources, Characteristics of effluent from a fertilizer industry.

(10 X3= 30 Marks)

PART B

(Answer any one full question from each Module)

MODULE I

11. a) What are the Environmental consequences of wastewater discharge from Thermal power plants?
    b) Explain the characteristics of waste water.

OR

12. Explain the Environmental consequences of wastewater discharge and the regulatory requirements for treatment and disposal of waste water.

MODULE II

13. Describe ASP. Starting from the material balance derive the expression for HRT and SRT for an ASP?

OR

14. Write a note on;
    1. Aerated lagoons
    2. Oxidation ditches
    3. UASB

MODULE III

15. a) List out the resin commonly used in ion exchange process.
    b) Explain Cationic and anionic exchange process.

OR

16. Discuss about various membrane seperation methods used for wastewater treatment

MODULE IV

17. Explain the various electrochemical treatment methods used in wastewater treatment

OR

18. Discuss in detail about advanced oxidation processes.

MODULE V

19. Explain the Characteristics, methodology and process for the treatment of effluent from beverage industry.

OR

20. Develop a flow sheet for the treatment of effluents from Sugar industry. And explain all Processes. Explain the typical problem arising in various units.

(5 X14= 70 Marks)

****

SYLLABUS

MODULE I (4 Hrs.):

Water Pollution and Treatment: Advanced Wastewater Treatment: Need and purpose of Advanced WWT: Characteristics of wastewater – Physical, Chemical and Biological. Environmental consequences of wastewater discharge and the regulatory requirements for treatment and disposal treatment levels and available technologies. Legislations.

MODULE II (13 Hrs.)

Wastewater Treatment: Primary treatment: Screening, Grit removal, Neutralization, equalization, Sedimentation, Flotation (oil & grease removal), Air stripping Secondary treatment: principles of waste treatment, basic kinetic equation, continuous flow treatment models, oxygen requirement in aerobic process, production of sludge. Conventional biological process: Activated Sludge Process (ASP)- development of material balance equations, UASB and Trickling Filters. Biological waste treatment: RBC, Nitrogen removal: Nitrification and denitrification process, phosphorous removal, tube aeration system, anaerobic filters. Low cost wastewater treatment: Aerated lagoons, stabilization ponds, oxidation ditches.

MODULE III (10 Hrs.)

Advanced Treatment Options: Tertiary treatment – ion exchange, Membrane separation Techniques: Brief description of MF, UF, NF membranes. Reverse osmosis principle, Membrane materials, Types of membranes – Plate & frame, tubular, hollow fibre, spiral wound membranes. Evaporators: forces evaporation, Multiple effect evaporators – falling film, raising film, forced circulation, agitated thin film driers.

MODULE IV (10 Hrs.)

Electrochemical Wastewater Treatment Processes: Introduction, Electro-coagulation : Factors affecting Electrocoagulation, Electrode materials , Reactor configurations. Electro-floatation : Factors affecting electro floatation, Comparison with other technology, Reactor configurations, Electro-oxidation : Electro oxidation process, Reactor configurations.

Advanced Oxidation Processes: Theory of advanced oxidation, Types of oxidizing agents, ozone based and non- ozone based processes, Fenton and photo-Fenton Oxidation. Solar Photo Catalytic Treatment Systems.

MODULE V (8 Hrs.)

Industrial Wastewater Treatment: Sources, Characteristics, methodology and process for the treatment of industrial wastes of sugar industry- beverage industry – tannery industry – textile mill waste industry – fertilizer plant – steel plant – oil refinery – paper and pulp mill. Sources, Characteristics, methodology and process for the treatment of Municipal waste water. Operational problems encountered in treatment plants: typical problems arising in various units, trouble shooting. Cleaner technologies: Water conservation.

Reference books

1. Weber, W.J. and DiGiano, F.A. "Process Dynamics in Environmental Systems". Wiley Interscience. ISBN: 0471017116
2. McCarty, P., and Rittmann, B., "Environmental Biotechnology: Principles and Applications", McGraw Hill, 2000. ISBN: 0072345535
3. Mark.J.Hammer & Mark.J.Hammer Jr., Water and Wastewater Technology, Prentice Hall of India. Ltd.

Text books: -

1. Metcalf & Eddy, "Wastewater Engineering – Treatment and Reuse", Revised by G.Tchobanoglous, F. L. Burton, and H. D. Stensel, 4th edition. Tata McGraw-Hill, 2003.
2. Casey, T.J., "Unit Processes in Water and Wastewater Engineering". Wiley Interscience, 1997. ISBN: 0471966932
3. W.W. Eckenfelder, "Industrial Water Pollution Control", Mc-Graw Hill, 1999

Course content and lecture schedule

No	Topic	No. of Lectures
1	**MODULE I- Water Pollution and Treatment (4 Hrs.)**	
1.1	Introduction on waste water treatment, Types of Sources, quality of water, Characteristics of waste water.	1
1.2	Various stages of Waste Water treatment process: aeration, Sedimentation, Filtration: slow and rapid sand filters.	1
1.3	Environmental consequences of wastewater discharge and the regulatory requirements for treatment and disposal treatment levels and available technologies. Legislations.	2
2	**MODULE 2- Wastewater Treatment (13 Hrs.)**	
2.1	Characteristics of waste water and treatment plant effluents, Dissolved oxygen.	1
2.2	Primary treatment: Screening, Grit removal, Neutralization, equalization, Sedimentation, Flotation (oil & grease removal)	2
2.3	Air stripping Secondary treatment: principles of waste treatment, basic kinetic equation, continuous flow treatment models, oxygen requirement in aerobic process, production of sludge.	2
2.4	Conventional biological process: Activated Sludge Process (ASP), UASB and Trickling Filters.	1
2.5	Biological waste treatment: RBC, Nitrogen removal: Nitrification and denitrification process, Phosphorus removal by Chemical Precipitation: Principles of process, Chemicals applied, Chemistry of phosphorus precipitation, Process configuration, Phosphorus removal by Biological Precipitation: Principles of the process, Microorganisms involved in the process, Process configurations	3
2.6	Utube aeration system, anaerobic filters.	2
2.7	Low cost wastewater treatment: Aerated lagoons, stabilization ponds, oxidation ditches	2
3	**MODULE 3- Advanced Treatment Options (10 Hrs.)**	
3.1	Tertiary treatment – ion exchange -Fundamentals of Ion Exchange, Types of Ion Exchange, Resins Theory of Ion Exchange, Applications: Removal and recovery of heavy metals, Removal of nitrogen , Removal of phosphorus , Organic chemical removal	3
3.2	Membrane separation Techniques: Brief description of MF, UF, NF membranes. Reverse osmosis principle, Membrane materials, Types of membranes – Plate & frame, tubular, hollow fibre, spiral wound membranes, application of membranes in various industrial applications.	3

3.3	Electro chemical techniques: electro dialysis, electro coagulation, Factors affecting Electrocoagulation, Electro-floatation : Factors affecting electro floatation Comparison with other technology, Reactor configurations Electro-oxidation : Electro oxidation process, Reactor configurations	2
3.4	Evaporators: forces evaporation, Multiple effect evaporators – falling film, raising film, forced circulation, agitated thin film driers.	2
3.5	Advanced oxidation processes, photo catalysis.- Theory of advanced oxidation, Types of oxidizing agents, ozone based and non-ozone based processes Fenton and photo-Fenton Oxidation Solar Photo Catalytic Treatment Systems	2
4	**MODULE 4- Electrochemical Wastewater Treatment Processes (10 Hrs.)**	
4.1	Introduction, importance of sewage, Characteristics of sewage, Sampling and analysis of sewage.	1
4.2	Sewage treatment and disposal: Skimming, Grit chamber, Sedimentation tanks, Septic tank.	2
4.3	Secondary treatment-types of filters, rate of filter loading, Activated sludge process, sludge digestion, Sludge disposal.	3
5	**MODULE 5- Industrial Wastewater Treatment (8 Hrs.)**	
5.1	Sources, Characteristics, methodology and process for the treatment of industrial wastes of sugar industry- beverage industry – tannery industry – textile mill waste industry – fertilizer plant – steel plant – oil refinery – paper and pulp mill.	5
5.2	Sources, Characteristics, methodology and process for the treatment of Municipal waste water.	1
5.3	Operational problems encountered in treatment plants: typical problems arising in various units, trouble shooting.	1
5.4	Cleaner technologies: Water conservation.	1

CHT 398	MODERN CONTROL THEORY	CATEGORY	L	T	P	CREDIT
		VAC	3	1	0	4

Preamble : The aim of the subject is to develop the methods of representation of systems and their transfer function models. To provide adequate knowledge in the time response of systems and steady state error analysis. To accord basic knowledge in obtaining the open loop andclosed–loop frequency responses of systems. To understand the concept of stability of control system and methods of stability analysis.

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

CO 1	Solve numerical problems on state space theorem
CO 2	Prove Cayley-Hamilton theorem
CO 3	Develop solutions of state equations.
CO 4	Define stability and find stability analysis using Liapunov theorm.
CO 5	Find stability of nonlinear systems using Krasovski method and variable gradient method.

Mapping of course outcomes with program outcomes

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

Assessment Pattern

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination**
	1	**2**	
Remember	10	10	10
Understand	20	20	20
Apply	20	20	70
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

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

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

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Obtain the state model of the system whose transfer function is given .

2. Explain the basic elements of a state diagram?.

3. Explain state vector, input vector, output vector.

Course Outcome 2 (CO2)

1. State and prove Cayley Hamilton theorem

2. Explain Quadratic forms and sign definiteness of Quadratic forms .

3. Find the state transition matrix of any 3x3 matrix.

Course Outcome 3(CO3):

1. Obtain the time response of the system :

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 0 & 3 \\ -2 & -5 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0 \\ 2 \end{bmatrix} u$$

Where u (t) is the unit step function occurring at t=0

2. Find the transfer function of the system whose governing equations are as given.

3. Derive any one method of solution of non homogeneous state equations.

Course Outcome 4 (CO4):

1. Explain stability, asymptotic stability and instability using suitable physical models.

2. State and explain the Lyapunov stability theorems.

3. Derive transfer function of a system from its state model

Course Outcome 5 (CO5):

1. Give the procedure to get a Lyapunov function using variable gradient method.

2. Use the variable gradient method to investigate the stability of equilibrium state of a nonlinear system

3. Explain Controllability and Observability .

Model Question paper

Name :

Reg no :

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
SIXTH SEMESTER B.TECH. DEGREE EXAMINATION,MONTH AND YEAR

Course code CHT 398

Time : 3 hours **Max. Marks: 100**

Modern control Theory

(2019 Scheme)

Part A

(Answer all questions. All questions carry three marks.)

1. What are state variables and equilibrium form?
2. What is Bush form?
3. What is inverse of matrix?
4. What is state transition matrix?
5. Explain state space representation.
6. What is transfer matrix?
7. What are discrete systems?
8. Define Liapunov stability theorem.
9. Define Controllability.
10. Define Observability.

Part B

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

Q.no.	Module 1	Marks
1a	Obtain canonical state model of the system whose transfer function is $\dfrac{S+5}{(S+1)(S+2)(S+3)}$	**7**
1b	Explain the basic elements of a state diagram? Draw the block diagram of the system described by state model, $\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{bmatrix} = \begin{bmatrix} a_1 & a_2 & 0 \\ 1 & 0 & 1 \\ 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 1 \\ 0 \\ 0 \end{bmatrix} u; y = x_3$	**7**
	OR	
2a	Derive the state space representation of the system described the differential equation $\ddot{y} + 5\dot{y} + 4y = u$ and obtain suitable transformation to get the diagonalisation. Also write the new state representation.	**7**
2b	Find the Eigen values, Eigen vectors and Jordan form representation of the following matrix. $\begin{bmatrix} 4 & 1 & -2 \\ 1 & 0 & 2 \\ 1 & -1 & 3 \end{bmatrix}$	**7**

Q.no.	Module 2	Marks
3	State and prove Cayley Hamilton theorem and Explain Quadratic forms and sign definiteness of Quadratic forms	**14**
	OR	
4a	Compute the state transition matrix of the system $\dfrac{dx}{dt} = Ax, where\ A = \begin{bmatrix} -3 & 1 & 0 \\ 0 & -3 & 1 \\ 0 & 0 & -2 \end{bmatrix}$ With the use of the Laplace transform.	**7**
4b	Find f(A)=A^{10} for $A = \begin{bmatrix} 0 & 1 \\ -1 & -2 \end{bmatrix}$	**7**

Q.no.	Module 3	Marks

5a A system has the system matrix A as given below: **7**

$$A = \begin{bmatrix} 2 & -1 & 1 \\ 1 & 1 & -1 \\ 1 & 3 & 1 \end{bmatrix}$$

Find the unforced solution of the system if initial condition is given by $x(0) = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}$

5b Derive any one method of solution of non homogeneous state equations? **7**

OR

6a Obtain the time response of the system : **7**

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 0 & 3 \\ -2 & -5 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0 \\ 2 \end{bmatrix} u$$

Where u (t) is the unit step function occurring at t=0.

6b Find the transfer function of the system whose governing equations are as given below: **7**

$$\dot{x}_1 = -4x_1 - x_2 + 3u$$

$$\dot{x}_2 = -2x_1 - 3x_2 + 5u, y = x_1 + 2x_2$$

Q.no.	**Module 4**	**Marks**
7a	Define stability, asymptotic stability and instability in the sense of Liapunov. (Use suitable figures)	**7**
7b	A discrete time system has the transfer function $\frac{Y(z)}{U(z)} = \frac{4z^3 - 12z^2 + 13z - 7}{(z-1)^2(z-2)}$ .Determine the state model of the system in Jordan Canonical form.	**7**

OR

8a Derive transfer function of a system from its state model: **7**

$$x(k+1) = Ax(k) + Bu(k)$$

$$y(k) = Cx(k) + Du(k)$$

8b A discrete time system has state equation given by **7**

$x(k+1) = \begin{bmatrix} -6 & 2 \\ -6 & 1 \end{bmatrix} x(k)$,

Use Cayley Hamilton approach to find out the state transition matrix.

Q.no.	Module 5	Marks
9a	Use the variable gradient method to investigate the stability of equilibrium state of a nonlinear system described by the equations $\dot{x_1} = -x_1 + 2x_1^2 x_2$ $\dot{x_2} = -x_2$	7
9b	Choose a quadratic scalar form and determine the stability of the system described by $\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -3 & -4 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$	7
	OR	
10a	Give the procedure to get a Liapunov function using variable gradient method.	7
10b	Consider the nonlinear system $\dot{x_1} = -x_1 - {x_2}^2$ $\dot{x_2} = -x_2$ Find a region of asymptotic stability using Krasovski method.	7

Syllabus

Module 1 (9 Hrs.)

Introduction to state space analysis-Definitions of state space, state variables and equilibrium points-representations of systems described by differential equations and transfer functions in state variable form-Bush form, Canonical form, Jordans form

Module 2 (9 Hrs.)

Cayley-Hamilton theorem- Evaluation of Matrix polynomial, inverse of a matrix, state transition matrix . Quadratic forms and sign definiteness of quadratic forms State space analysis of control systems.

Module 3 (8Hrs.)

Solution of the time invariant state equations-state transition matrix. Transfer matrix. Linear time varying systems.

Module 4 (9 Hrs.)

Discrete systems-state space representation and solution. Liapunov stability analysis- Definition of stability, instability and asymptotic stability. Liapunov stability theorems.

Module 5 (10 Hrs.)

Stability analysis of simple linear systems. Stability analysis of non-linear systems-Krasovski method and variable gradient method. Controllability and Observability-Definitions

Text Books

1. Katsuhiko Ogata, *Modern control engineering*, Prentice- Hall of India, Fifth edition 2015.

2. Chen,C.F and I.J Haas, *Elements of control system analysis*, Prentice Hall, First edition 1968

Reference Books

1. Katsuhiko Ogata, *State space analysis of control systems*, Prentice hall, First edition 1967

2. Kuo,B.C, *Analysis and synthesis of sampled data control systems*, Prentice Hall, First edition 1963

3. A.Nagoor Kani, *Advanced Control Theory*, RBA Publications. Second edition 1999

4. A K Jairath, *Modern Control Theory*, Ane books, Second edition, 2015

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**State space analysis (9 Hrs.)**	
1.1	Introduction to state space analysis	1
1.2	Definitions of state space, state variables and equilibrium points	1
1.3	Representations of systems described by differential equations and transfer functions in state variable form	1
1.4	Bush form	2
1.5	Canonical form	2
1.6	Jordan form	2
2	**Matrix calculations. (9 Hrs.)**	
2.1	Cayley-Hamilton theorem	2
2.2	Evaluation of Matrix polynomial	1
2.3	Inverse of a matrix, state transition matrix	2
2.4	Quadratic forms and sign definiteness of quadratic forms	2
2.5	State space analysis of control systems	2
3	**State space concept. (8Hrs.)**	
3.1	Solution of the time invariant state equations	2
3.2	State transition matrix	2
3.3	Transfer matrix	2
3.4	Linear time varying systems	2
4	**Stability analysis. (9 Hrs.)**	
4.1	Discrete systems-state space representation and solution.	2
4.2	Liapunov stability analysis-	1
4.3	Definition of stability, instability and asymptotic stability.	3
4.4	Liapunov stability theorems.	3
5	**Applications. (10 Hrs.)**	
5.1	Stability analysis of simple linear systems	2
5.2	Stability analysis of non-linear systems-	2
5.3	Krasovski method	2
5.4	Variable gradient method. Controllability and Observability-Definitions	2
5.5	Controllability and Observability- Definitions	2