SEMESTER -3

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

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

Prerequisite: Basic knowledge in Engineering Chemistry

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

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

Mapping of course outcomes with program outcomes

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

Assessment Pattern

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

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

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

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

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Describe the principle and instrumentation of amperometric titration.

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

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

Course Outcome 2 (CO2)

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

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

3. Describe the working principle of Scanning Electron Microscopy.

Course Outcome 3(CO3):

1. Derive Nernst distribution law.

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

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

Course Outcome 4 (CO4):

1. Derive Langmuir adsorption isotherm.

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

3. Describe the mechanism of action of various surfactants.

Course Outcome 5 (CO5):

1. Describe the factors affecting nuclear stability.

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

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

Model Question paper

Reg No:______________

Name :______________

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

Course Code: CHT 201

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

CHEMISTRY FOR PROCESS ENGINEERING

(2019-Scheme)

PART A

(Answer all questions, each question carries 3 marks)

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

PART B

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

Module I

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

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

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

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

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

Module II

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

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

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

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

Module -III

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

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

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

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

Module -IV

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

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

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

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

Module -V

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

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

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

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

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Syllabus

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

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

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

Module 4: Adsorption and Surface Chemistry –Adsorption, Adsorption Isotherms – Langmuir, Freundlich and BET, Gibbs adsorption isotherm – derivation. Colloids –, Protective colloids, Gold number, Zeta potential, Emulsion, Micelles- Critical micelle concentration, Micellar catalysis. Surfactants.

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

Text Books

1. B. R. Puri, L.R. Sharma, M.S. Pathania, Principles of Physical Chemistry, Vishal Publishing Co., 2013.

2. R. L. Madan and G. D. Tuli *Physical Chemistry,* published by S. Chand Publishing, Edition 2016
3. A. Bahl, B. S Bhal and G D Tuli, Essentials of Physical Chemistry, S. Chand Publishing, Edition 2010

Reference Books

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

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

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

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

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

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

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

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

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

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

Course Contents and Lecture Schedule

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

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

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

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

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

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

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

Mapping of course outcomes with program outcomes

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

Assessment Pattern

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

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern

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

End Semester Examination Pattern:

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

Course Level Assessment Questions

Course Outcome 1 (CO1): Distinguish and summarize various unit operations & unit processes.

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

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

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

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

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

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

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

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

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

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

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

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

   (i)Weight of salt precipitated per hour.

   (ii) Weight of concentrated liquor leaving per hour.

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

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

   Data:

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

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

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

ΔH_{vap} = 26900 kcal/kmol

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

   Data: Specific heats of products of combustion in kcal/(kmol.^oK)

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

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

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

   where T = temperature in Kelvin

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

Model Question Paper

QP CODE: **PAGES: 3**

Reg No:______________

Name: ______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIRST SEMESTER B.TECH DEGREE EXAMINATION,MONTH & YEAR

Course Code: CHT 203

Max. Marks: 100 Duration: 3 Hours

CHEMICAL PROCESS PRINCIPLES

PART – A

Answer All the Questions(10 x 3 = 30)

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

PART – B

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

Module 1

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

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

OR

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

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

i) Composition in weight %

ii) Average molecular weight

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

Module 1I

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

OR

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

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

ModuleIII

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

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

OR

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

ModuleIV

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

OR

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

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

Module V

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

OR

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

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

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

(b) Calculate standard heat of the following reaction:

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

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

Syllabus

Module 1

Introduction to Chemical Engineering, Chemical process Industry, Unit Operations and Unit Processes. Units and Dimensions: System of Units, Basic and Derived quantities, Conversion of units, Conversion of equations- problems. Density and Specific gravity - Specific Gravity Scales.

Concepts of atomic weight, equivalent weight and mole. Composition of solids, liquids and solutions - weight percent, mole percent, molarity, normality, molality, ppm

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

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

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

Module 2

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

Module 3

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

Module 4

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

Module 5

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

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

Text Books:

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

Reference Books:

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

Course Contents and Lecture Schedule:

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

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

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

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

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

Prerequisite: Nil

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

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

Mapping of course outcomes with program outcomes

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

Assessment Pattern

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

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

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

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

Course Level Assessment Questions

Course Outcome 1 (CO1): To apply the basic properties and transport laws to fluid in different conditions like statics and dynamics

1. Differentiate between absolute viscosity and apparent viscosity.

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

3. Define Pascal's law.

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

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

2. Derive momentum balance equation.

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

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

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

2. Write the applications of friction factor chart.

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

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

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

1. Derive the equation for minimum fluidization Velocity.

2. Define Drag Coefficient.

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

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

(Critical superficial velocity assuming єm = 0.55)

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

1. Compare Rotary pumps and Reciprocating pumps.

2. What are characteristics curves in centrifugal pump?

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

Model Question paper

QP CODE: **Reg No:______________**

PAGES:3 **Name :______________**

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

Course Code: CHT 205

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

CHT 205 FLUID AND PARTICLE MECHANICS

(2019-Scheme)

PART A

(Answer all questions, each question carries 3 marks)

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

PART B

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

MODULE I

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

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

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

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

MODULE II

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

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

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

MODULE III

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

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

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

(7+7 = 14 marks)

MODULE IV

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

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

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

MODULE V

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

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

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

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

Syllabus

Module 1

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

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

Module 2

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

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

Module 3

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

Module 4

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

Module 5

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

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

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

Reference Books

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

Course Contents and Lecture Schedule

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

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

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

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

Prerequisite: Nil

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

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

Mapping of course outcomes with program outcomes

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

Assessment Pattern

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	75	75	2.5 hours

Continuous Internal Evaluation Pattern:

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

End Semester Examination Pattern

The following guidelines should be followed regarding award of marks

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

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

Course Level Assessment Questions

Course Outcome 1 (CO1):

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

Course Outcome 2 (CO2)

1.Find the viscosity of the given oil at different temperatures using Redwood viscometer.

2. Estimate the BOD of the given sample of water using BOD incubator.
3. Estimate the Calorific value of the given gas using Junkers Gas Calorimeter

Course Outcome 3(CO3):

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

Course Outcome 4 (CO4):

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

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

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

LIST OF EXPERIMENTS (Minimum of 8 mandatory)

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

Reference Books

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

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

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

Prerequisite: Basic knowledge in Engineering Chemistry Laboratory experiments

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

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

Mapping of course outcomes with program outcomes

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

Assessment Pattern

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	75	75	2.5 hours

Continuous Internal Evaluation Pattern:

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

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

(a) Preliminary work : 15 Marks

(b) Implementing the work/Conducting the experiment : 10 Marks

(c) Performance, result and inference (usage of equipments and trouble shooting) : 25 Marks

(d) Viva voce : 20 marks

(e) Record : 5 Marks

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

LIST OF EXPERIMENTS (Minimum of 8 mandatory)

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

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

Reference Books

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

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

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

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

SEMESTER -3

MINOR

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

Preamble:

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

Prerequisite: A basic course in chemistry and mathematics

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

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

Mapping of course outcomes with program outcomes

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

Assessment Pattern

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

Apply	20	20	20
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

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

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

Course Level Assessment Questions

Course Outcome 1 (CO1): Explain the history, role of chemical engineering and chemical engineering profession

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

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

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

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

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

2. Illustrate the equation of state

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

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

1. Differentiate physical adsorption and chemical adsorption

2. Explain any two polymerization reactions and its industrial application

3. Distinguish unit operations and unit processes with examples

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

1. Explain different modes of heat transfer with example
2. Distinguish between laminar and turbulent flow
3. Explain different classification of chemical reactions with an example

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

1. Identify the basic information provided in the Process Flow Diagram
2. Explain the principle of venturimeter
3. Enumerate the need for using U-tube manometer

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

1. Identify the role of safety in chemical process industries.
2. Explain the importance of safety measure in chemical industries with the help of Bhopal incident
3. Describe an industrial wastewater treatment facility

Model Question paper

QP Code:

Reg No.:_______________ Name:___________________________

Course Code: CHT 281

Course Name: INTRODUCTION TO CHEMICAL ENGINEERING

Max. Marks: 100 Duration: 3 Hours

(2019-Scheme)

PART A

Answer all questions, each carries 3 marks.

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

2. Point out the major fields of application of Chemical Engineering

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

4. Illustrate the equation of state.

5. Distinguish between extraction and leaching

6. Classify the size reduction equipments with one example

7. Explain different modes of heat transfer

8. Define the order of reaction and molecularity of a chemical reaction.

9. How solid wastes are classified?

10. State any 3 general process hazards that may arise in an industry

(10x3=30)

PART B

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

Module –1

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

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

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

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

Module –2

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

b) Differentiate molarity, molality and normality.

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

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

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

Module –3

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

b) Explain saponification process and its industrial application

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

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

Module –4

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

b) With a schematic diagram explain working of a venturimeter

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

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

Module –5

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

b) Describe solid waste management

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

1. b) Discuss a typical wastewater treatment system

Syllabus

Module 1

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

Module 2

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

Module 3

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

Module 4

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

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

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

Module 5

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

Text Books

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

Reference Books

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

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

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

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

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

SEMESTER -4

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

Preamble:

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

Prerequisite: Knowledge of fundamental Physics, Chemistry and Mathematics

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

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

Mapping of course outcomes with program outcomes

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

Assessment Pattern

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

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

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

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

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Explain the application of the Zeroth law of thermodynamics in temperature measurement

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

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

Course Outcome 2 (CO2)

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

2. Define primary properties and energy properties

3. Differentiate between reversible and irreversible processes

Course Outcome 3(CO3):

1. Derive the fundamental property relations

2. Derive Clausius- Clapeyron equation from fundamental property relations

3. Derive expression for Joule-Thomson coefficient in terms of measurable properties

Course Outcome 4 (CO4):

1. Define partial molar properties.

2. Define chemical potential.

3. Define excess properties.

Course Outcome 5 (CO5):

1. Illustrate VLE for completely miscible system with the help of a neat phase diagram.

2. Explain with a neat phase diagram the VLLE in a partially miscible system

3. Explain the vapour liquid equilibria in a system of two immiscible liquids

Course Outcome 6 (CO6):

1. Explain the different methods of determination of equilibrium constant of a given reaction

2. Derive the effect of temperature on equilibrium constant

3. Obtain the degrees of freedom of gaseous system containing CO, CO_2, N_2, O_2 and CH_4

Model Question paper

QP CODE: PAGES:4

Reg No:______________

Name :______________

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

MONTH & YEAR

Course Code: CHT202

Max. Marks: 100 Duration: 3 Hours

CHEMICAL ENGINEERING THERMODYNAMICS

(2019-Scheme)

Part A

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

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

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

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

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

(10 × 3 = 30 marks)

PART B

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

Module - I

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

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

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

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

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

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

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

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

Module - II

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

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

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

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

Module - III

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

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

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

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

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

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

Module - IV

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

b. Explain the principle steam distillation. (5)

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

The vapour pressures of the pure liquids are given below:

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

Module - V

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

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

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

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

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

Given: K_a at 298.15 is 8.685×10^{-6}

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

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

Syllabus

Module 1

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

Module 2

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

Module 3

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

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

Module 4

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

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

Module 5

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

Text Books

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

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

Reference Books

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

Course Contents and Lecture Schedule

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

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

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

Preamble:

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

Prerequisite: Basic knowledge in Engineering Science

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

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

Mapping of course outcomes with program outcomes

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

Assessment Pattern

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

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

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

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

Course Level Assessment Questions

Course Outcome 1 (CO1): Identify and distinguish various modes of heat transfer and examine the mechanisms involved

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

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

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

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

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

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

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

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

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

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

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

Model Question Paper

QP CODE: PAGES: 2

Reg No:……………______________

Name :…………….______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIRST SEMESTER B. TECH DEGREE EXAMINATION,MONTH & YEAR

Course Code: CHT 204

Max Duration: 3 Hours Marks:100

HEAT TRANSFER OPERATIONS

(2019 Scheme)

PART A

(Answer all questions, each question carries 3 marks)

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

PART B

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

Module -I

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

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

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

Module -II

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

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

(14 marks)

Module -III

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

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

Module -IV

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

18. a. Using a neat diagram describe the construction of a shell and tube heat exchanger.

(8 marks)

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

Module -V

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

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

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

Syllabus

Module 1 (Conduction)

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

Module 2 (Convection)

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

Module 3 (Radiation, Boiling and Condensation)

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

Module 4 (Heat Exchangers)

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

Module 5 (Evaporators)

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

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

Reference Books

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

Course Contents and Lecture Schedule

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

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

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

	merits and demerits. .	

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

Preamble:

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

Prerequisite: NIL

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

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

Mapping of course outcomes with program outcomes

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

Assessment Pattern

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

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

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

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

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. State the functionality of a finite state machine and the microprocessor.

2. List the microprocessors launched by various company.

3. Define the functionality of a microprocessor.

Course Outcome 2 (CO2)

1. State the functionality of Program counter in a microprocessor

2. List the registers present in x86 microprocessors.

3. Define the functionality of a stack and stack pointer

Course Outcome 3(CO3):

1. Demonstrate the segment override instructions in x86
2. Give example for accessing content in the data segment
3. Describe the functionality of the branch instructions.

Course Outcome 4 (CO4):

1. Demonstrate the memory segmentation for x86 architecture.
2. Give example for generating physical address for accessing data segment.
3. Describe the functionality of the pipeline mechanism in X86

Course Outcome 5 (CO5):

1. Illustrate the accessing of data segment by various addressing mode.
2. Show the program for accessing a stack segment in x86
3. Demonstrate the operation of stack and stack pointer through push and pop Instructions.

Course Outcome 6 (CO6):

1. Illustrate that how to handle interrupts in x86 architecture
2. Show the program for accessing a maskable interrupt in x86
3. Demonstrate the operation of PPI -8252 with proper mapping diagram

Model Question paper

QP CODE: **PAGES:3**

Reg No:______________ **Name :______________**

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY FIRST SEMESTER

B.TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: CHT 206

Max. Marks: 100 Duration: 3 Hours

PARTICLE TECHNOLOGY

(2019-Scheme)

Part A

(Answer all questions, each question carries 3 marks)

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

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

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

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

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

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

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

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

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

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

PART B

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

Module 1

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

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

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

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

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

Module 2

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

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

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

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

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

Module 3

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

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

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

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

Module 4

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

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

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

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

Module 5

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

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

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

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

Syllabus

Module 1

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

Module 2

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

Module 3

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

Module 4

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

Module 5

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

Text Books

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

Reference Books

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

Course Contents and Lecture Schedule

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

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

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

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

Prerequisite: Course in Fluid & Particle Mechanics

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

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

Mapping of course outcomes with program outcomes

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

Assessment Pattern

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	75	75	2.5 hours

Continuous Internal Evaluation Pattern:

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

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

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

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

Course Level Assessment Questions

Course Outcome 1 (CO1):

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

Course Outcome 2 (CO2)

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

Course Outcome 3(CO3):

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

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

Course Outcome 4 (CO4):

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

LIST OF EXPERIMENTS (Minimum of 8 mandatory)

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

Reference Books

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

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

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

Prerequisite: CHT 206 Particle Technology

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

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

Mapping of course outcomes with program outcomes

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

Assessment Pattern:
Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	75	75	2.5 hours

Continuous Internal Evaluation Pattern:

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

End Semester Examination Pattern:

The following guidelines should be followed regarding award of marks

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

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

Syllabus

List of Experiments:

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

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

Reference books:

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

Details of course content:

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

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

SEMESTER -4
MINOR

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

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

Prerequisite: Introduction to Chemical engineering

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

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

Mapping of course outcomes with program outcomes

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

Assessment Pattern

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

Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

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

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

Course Level Assessment Questions

Course Outcome 1 (CO1): Impart the basic concepts of safety in Process Industries.

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

2. State key safety practices in an oil refinery

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

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

1. List the classification of fire

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

3. Describe BLEVE.

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

1. List the physical hazards present in a process industry

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

3. Describe health hazards due to chemical exposures

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

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

2. Illustrate HAZCHEM CODE, TREM CARD

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

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

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

2. Describe Event tree analysis

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

Model Question paper

QP CODE: **Reg No:_______________**

PAGES:3 **Name :_______________**

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

Course Code: CHT 282

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

CHT 282 SAFETY ENGINEERING OF PROCESS PLANTS

(2019-Scheme)

PART A

(Answer all questions, each question carries 3 marks)

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

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

PART B

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

MODULE I

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

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

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

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

MODULE II

13. What are the potential fire hazards in Petroleum and petrochemical industries? Explain

    (14 marks)

14. Explain in detail about the fixed fire protection system for a storage tank contains Naphtha.

    (14 marks)

MODULE III

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

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

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

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

MODULE IV

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

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

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

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

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

MODULE V

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

b) Explain the OR and AND gate rules with examples. (8+6=14 marks)

20.a) Develop a methodology for HAZOP technique as a tool for hazard identification.

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

(8+6 =14 marks)

Syllabus

Module 1

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

Module 2

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

Module 3

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

Module 4

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

Module 5

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

Reference Books

1. B. K. Bhaskara Rao, Er. R. K. Jain , Vineet Kumar, " Safety in Chemical Plants/Industry and Its Management", Khanna Publishers, First edition, 2010

2. R.K.Jain & Sunil S Rao, Industrial Safety, Health and Environment Management Systems, Khanna Publishers, Fourth Edition,2000

3. Encyclopaedia of Occupational Health & Safety, International labour Office, Geneva, 2012

4. Frank P. Lees- "Loss Prevention in Process Industries" ,Vol.1,2&3,Second Edn, Butterworth-Heinemann.1996

5. Guidelines for Hazard Evaluation Procedure. Centre for Chemical Process Safety.AICHE,1992

6. K.V. Raghavan and A. A. Khan : Methodologies in Hazard Identification and assessment Manual by CLRI, December 1990.

Course Contents and Lecture Schedule

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

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

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

Preamble:

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

Prerequisite: Nil

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

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

Mapping of course outcomes with program outcomes

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

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	10
Understand	40	20	60
Apply		20	30
Analyse			

Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

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

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

Course Level Assessment Questions

Course Outcome 1 (CO1): Understand the fundamentals of petroleum geology and exploration.

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

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

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

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

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

   Reservoir pressure = 2,000 psia

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

   IPR model parameter, n = 0.8

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

   GWC = 9700 ft ; Centroid depth = 9537 ft

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

   ϕ = 0.19; S_{wc} = 0 20; γ_g = 0.85

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

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

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

   a) Calculate the volume of the GIIP.
   b) It is intended to enter a gas sales contract in which the following points have been stipulated by the purchaser.
      1. During the first two years, a production rate build-up from zero – 100 MMscf/d (million) must be achieved while developing the field
      2. The plateau rate must be continued for 15 years at a sales point delivery pressure which corresponds to a minimum reservoir pressure of 1200 psia. Can this latter requirement be fulfilled? (Assume that the aquifer is small so that the depletion material balance equation can be used).
   c) Once the market requirement can no longer be satisfied the field rate will decline exponentially by 20% per annum until it is reduced to 20 MMscf/d.

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

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

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

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

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

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

Model Question paper

QP CODE: PAGES: 3

Reg No: _____________

Name: _____________

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

Course Code: CHT 284

Max. Marks: 100 Duration: 3 Hours

FUNDAMENTALS OF OIL AND NATURAL GAS ENGINEERING

(2019-Scheme)

PART A

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

1 List the failures of inorganic theory.

2 Differentiate between absolute permeability and effective permeability.

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

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

5 Define reservoir deliverability and its significance.

6 Define recovery factor and its significance.

7 Explain the formation of tar sand.

8 Outline the composition of oil shales.

9 Explain biogenic and thermogenic coal bed methane formation.

10 Differentiate between shale gas and tight gas.

PART B

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

Module –I

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

to reservoir rock.

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

Module – II

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

Module – III

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

GWC = 9700 ft ; Centroid depth = 9537 ft
Net bulk volume (V) = $1.776 * 10^{10}$cu.ft
$\phi = 0.19$; S_{wc} = 0 20; $\gamma_g = 0.85$

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

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

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

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

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

Reservoir pressure = 2,000 psia

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

IPR model parameter, n= 0.8

Module – IV

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

Module – V

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

Syllabus

Module 1: Fundamentals of petroleum geology and exploration

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

Module 2: Introduction to well drilling and production

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

Module 3: Fundamentals of Oil and Gas Reservoir Engineering

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

Module 4: Non-Conventional Oil

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

Module 5: Non-conventional gas

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

Reference Books

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

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

Course Contents and Lecture Schedule

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

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

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

Preamble:

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

Prerequisite:

A basic course in physics and chemistry.

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

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

Mapping of course outcomes with program outcomes

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

Assessment Pattern

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

Understand	20	20	20
Apply	20	20	70
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks

Continuous Assessment Test (2 numbers) : 25 marks

Assignment/Quiz/Course project : 15 marks

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

Course Level Assessment Questions

Course Outcome 1 (CO1): Define qualitatively the structure and bonding schemes of solids.

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

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

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

3. Explain the technological properties of solid materials

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

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

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

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

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

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

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

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

Model Question Paper

QP CODE: PAGES:2

Reg No:______________

Name :______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIRST SEMESTER B.TECH DEGREE EXAMINATION,MONTH & YEAR

Course Code: CHT 286

Max. Marks: 100

Duration: 3 Hours

MATERIAL SCIENCE AND ENGINEERING

(2019-Scheme)

PART A

(Answer all questions , each question carries 3 marks)

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

PART B

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

Module -I

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

(b) Define Poisson's ratio.

Module -II

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

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

Module -III

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

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

Module -IV

17. Describe the mechanism and factors influencing corrosion

18. Explain the factors affecting the selection of materials.

Module -V

19. Explain in detail the history of nanotechnology.

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

Syllabus

Module 1 (Crystal Structure and Properties of Engineering Materials)

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

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

Module 2 (Solid solutions)

Solid solutions-types of solid solutions-Hume Rothery rules-intermediate phases-mechanical mixtures-phase diagrams-eutectic systems- peritectic system, eutectoid and peritectoid systems - carbon diagram-T-T-T diagram-plastic deformation-recrystallisation-hot and cold working of metals, Heat treatments-elementary study of various metals and alloys like cast iron,carbon steel,alloy steels.

Module 3 (Alloys and Composites)

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

Module 4 (Selection of Materials)

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

Module 5 (Nano and Smart Materials)

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

Reference Books

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

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

Course Contents and Lecture Schedule

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

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

SEMESTER -4
HONOURS

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

Preamble:

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

Prerequisite: Nil

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

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

Mapping of course outcomes with program outcomes

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

Assessment Pattern

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

Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

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

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

Course Level Assessment Questions

Course Outcome 1 (CO1):

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

Course Outcome 2 (CO2)

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

Course Outcome 3(CO3):

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

Course Outcome 4 (CO4):

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

Course Outcome 5 (CO5):

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

Model Question paper

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

Reg No:____________ **Name :______________**

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

Course Code: CHT 294

Max. Marks: 100 Duration: 3 Hours

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

(Answer all questions, each question carries 3 marks)

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

PART B

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

Module I

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

Module II

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

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

Module III

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

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

Module IV

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

Module V

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

Syllabus

Module 1

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

Module 2

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

Module 3

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

Module 4

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

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

Module 5

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

Text Books/

Reference Books

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

Instrumental Techniques, Marcel Dekker, inc.

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

Course Contents and Lecture Schedule

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

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

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

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

Prerequisite: Basic concepts of process instrumentation

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

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

Mapping of course outcomes with program outcomes

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

Assessment Pattern

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

Understand	20	20	30
Apply	20	20	60
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

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

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

Course Level Assessment Questions

Course Outcome 1 (CO1):

What you mean by sensitivity of an instrument

Course Outcome 2 (CO2)

Classify different temperature measuring instruments

Course Outcome 3(CO3):

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

Course Outcome 4 (CO4):

List the advantages & limitations of magnetic flow meter?

Course Outcome 5 (CO5):

Explain working principle of XRD

Course Outcome 6 (CO6):

Draw P&ID diagram for shell & tube heat exchanger

Model Question paper

QP CODE: **PAGES:3**
Reg No:______________
Name :______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY FIRST SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR
Course Code: CHT 296

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

MODERN METHODS OF INSTRUMENTATION

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

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

PART B

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

Module I

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

b) Explain static characteristics of instruments.(6)

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

b) Explain different class of instruments. (6)

Module II

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

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

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

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

Module III

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

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

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

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

Module IV

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

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

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

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

Module V

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

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

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

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

Syllabus

Module 1 (8 Hours)

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

Module 2 (8 Hours)

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

Module 3 (10 Hours)

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

Module 4 (9 Hours)

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

Module 5 (10 Hours)

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

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

Reference Books

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

Course Contents and Lecture Schedule

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

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

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

Preamble:

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

Prerequisite: Nil

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

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

Mapping of course outcomes with program outcomes

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

Assessment Pattern

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

Apply	40	40	80
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

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

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

Course Level Assessment Questions

Course Outcome 1 (CO1): Identify the errors, source of error and its effect on any numerical computations.

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

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

- Air at 25°C and 1 atm flows through a 4 mm diameter tube with an average velocity of 50 m/s. The roughness is ε = 0.0015 mm. Develop a MATLAB program based on Newton – Raphson method to determine the friction factor using the Colebrook equation.
  $$\frac{1}{f} = -2.0\ log\left(\frac{\varepsilon/D}{3.7} + \frac{2.51}{R_e\sqrt{f}}\right)$$
  Determine the pressure drop in a 1 m section of the tube using the relation
  $$\Delta P = \frac{fL\bar{V}\rho}{2D}$$
  Density of the air at 25°C and 1 atm is 1.23 kg/m^3 and the viscosity is 1.79 X 10^{-5} kg/ms.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Model Question paper

QP CODE: PAGES: 3

Reg No: ______________

Name: ______________

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

Course Code: CHT 292

Max. Marks: 100 Duration: 3 Hours

COMPUTATIONAL METHODS IN CHEMICAL ENGINEERING

(2019-Scheme)

PART A

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

1 Explain about the different errors encountered during numerical methods.

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

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

4 Write a note on instabilities of simultaneous equations.

5 Explain briefly about piecewise interpolation.

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

7 Differentiate between simple difference and divided difference.

8 Discuss the difference between Trapezoidal integration and Simpsons integration

9 Distinguish corrector formula from predictor formula.

10 Compare the Taylor series and Runge-Kutta methods.

PART B

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

Module –I

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

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

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

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

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

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

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

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

Module – II

13 a Solve the equations given below by Relaxation methods 9

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

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

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

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

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

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

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

Module – III

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

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

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

15 b Derive Newton's divided difference interpolation formula 7

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

intervals of time t (min) as follows:

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

Estimate approximately, the distance covered in 20 minutes.

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

Module – IV

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

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

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

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

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

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

Module – V

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

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

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

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

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

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

20 b Using modified Eulers method, obtain the solution of the differential equation $\frac{dy}{dx} = x + \sqrt{y}$ with initial condition y(0)=1, for range $0 \le x \le 0.4$ in steps of 0.2. 4

Syllabus

Module 1:

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

Module 2

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

Module 3

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

Module 4

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

Module 5

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

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

Reference Books

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

Course Contents and Lecture Schedule

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

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