M.TECH.

(CHEMICAL ENGINEERING)

(Effective from the admitted batch of 2021-22)

Scheme and Syllabi

DEPARTMENT OF CHEMICAL ENGINEERING
AU COLLEGE OF ENGINEERING
ANDHRA UNIVERSITY
VISAKHAPATNAM

Prof. G.M.J. Raju, M.Tech.,Ph.D.,
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DEPARTMENT OF CHEMICAL ENGINEERING
AU COLLEGE OF ENGINEERING
ANDHRA UNIVERSITY
VISAKHAPATNAM

SCHEME OF INSTRUCTION & EXAMINATION
1/2 M.TECH (CHEMICAL ENGG) FIRST SEMESTER
(WITH EFFECT FROM 2021-22 ADMITTED BATCH ONWARDS)
UNDER CHOICE BASED CREDIT SYSTEM

Code No.	Course	Credits	Theory	Tutorial	Lab	Total	Sessional marks	Exam marks	Total marks
CHEM 1.1.1	Chemical Reaction Engineering	3	3	1	--	4	30	70	100
CHEM 1.1.2	Transport phenomena	3	3	1	--	4	30	70	100
CHEM 1.1.3	Elective-I	3	4	--	--	4	30	70	100
CHEM 1.1.4	Elective-II	3	4	--	--	4	30	70	100
CHEM 1.1.5	Research Methodology & IPR	2	4	--	--	4	30	70	100
CHEM 1.1.6	Audit Course–1*	0	2	-	--	2	--	--	--
CHEM 1.1.7	Elective lab	2	--	--	3	3	50	50**	100
CHEM 1.1.8	Seminar	2	--	--	3	3	100	--	100
	TOTAL	18	20	2	6	28	300	400	700

*To be included as 'Qualified' or 'Not Qualified' in the marks list

**Only internal evaluation.

Elective-I: 1. Petroleum Refinery Engineering-I
2. Process Dynamics and control-I
3. Electrochemical Engineering-I

Elective-II: 1. Corrosion Engineering-I
2. Energy Engineering-I
3. Reaction Engineering-I

Audit Course 1: 1. Yoga for working professionals
2. Organizational Behaviour

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SCHEME OF INSTRUCTION & EXAMINATION
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UNDER CHOICE BASED CREDIT SYSTEM

Code No.	Course	Credits	Theory	Tutorial	Lab	Total	Sessional marks	Exam marks	Total marks
CHEM 1.2.1	Computer aided design	3	3	1	--	4	30	70	100
CHEM 1.2.2	Process Dynamic and Control	3	3	1	--	4	30	70	100
CHEM 1.2.3	Advanced mass transfer	3	3	1	--	4	30	70	100
CHEM 1.2.4	Elective-III	3	4	--	--	4	30	70	100
CHEM 1.2.5	Elective-IV	3	4	--	--	4	30	70	100
CHEM 1.2.6	Audit Course–2*	0	2	-	--	2	--	--	--
CHEM 1.2.7	Elective lab	2	--	--	3	3	50	50	100
CHEM 1.2.8	Seminar	2	--	--	3	3	100	--	100
	TOTAL	19	19	3	6	28	300	400	700

*To be included as 'Qualified' or 'Not Qualified' in the marks list

Elective-III: 1. Petroleum Refinery Engineering-II
2. Process Dynamics and control-II
3. Electrochemical Engineering-II

Elective-IV: 1. Corrosion Engineering-II
2. Energy Engineering-II
3. Reaction Engineering-II

Audit Course 2 : 1. Disaster Management
2. Entrepreneurship

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SCHEME OF INSTRUCTION & EXAMINATION
2/2 M.TECH (CHEMICAL ENGG) FIRST SEMESTER
(WITH EFFECT FROM 2021-22 ADMITTED BATCH ONWARDS)
UNDER CHOICE BASED CREDIT SYSTEM

Code No.	Course	Credits	Theory	Tutorial	Lab	Total	Sessional marks	Exam marks	Total marks
CHEM 2.1.1	Elective-V	3	4	--	--	4	30	70	100
CHEM 2.1.2	Elective-VI (Open Elective)	3	4	--	--	4	30	70	100
CHEM 2.1.3	Dissertation (preliminary)	9	--	--	--	--	100	--	100
	TOTAL	15	8	--	--	8	160	140	300

Note: The dissertation shall be evaluated through Viva-voce examination by a committee with HOD, Chairman, Board of Studies and Research guide as members. The marks shall be awarded in the ratio of 30,30 and 40 percent by the members Respectively

Elective-V: 1. Process modelling and Simulation
2. Computational Methods
3. Advanced Engineering Mathematics and Statistics

Elective-VI: 1. Nano Technology
2. Pollution Control
3. Corrosion Engineering

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(WITH EFFECT FROM 2021-22 ADMITTED BATCH ONWARDS)
UNDER CHOICE BASED CREDIT SYSTEM

Code No.	Course	Credits	Theory	Tutorial	Lab	Total	Sessional marks	Exam marks	Total marks
CHEM 2.2.1	Dissertation	16	--	--	--	--	--	100	100
	TOTAL	16	--	--	--	--	--	100	100

Note: The dissertation shall be evaluated through Viva-voce examination by a committee with an external member nominated by University, HOD, Chairman, Board of Studies and Research guide as members. The marks shall be awarded in the ratio of 20, 20, 20 and 40 percent by the members respectively

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M.Tech. Chemical Engineering

Program Outcomes

PO1 Carryout independently research/investigation and development work to solve practical problems in Chemical Industry

PO2 Write and present a substantial technical report/document.

PO3 Develop comprehensive understanding of Chemical Engineering

PO4 Develop skills to work with multidisciplinary fields like biotechnology, refinery, processing industry, etc. and to tackle any engineering related tasks

PO5 Solve the global, economic, environmental and social issues

PO6 Function effectively as a Chemical Engineering professional as an individual and as a member or leader in diverse technical teams

PO7 Develop confidence for self-learning and ability for lifelong learning.

Program Specific Outcomes

PSO1 Identify, formulate and solve problems of the Chemical Engineering and inter disciplinary areas with critical thinking, professional ethics, social responsibility and management skills

PSO2 Apply the technical knowledge to solve the problems of Chemical and allied industries and society

SYLLABUS
M.TECH. I SEMESTER
CHEM-1.1.1: Chemical Réaction Engineering
(Common for Chemical, MPE, CACE & IPCE)

Objectives:

- To focus on the thermal characteristics of various reactions and the design aspects of non isothermal and adiabatic reactors
- To focus on Heterogeneous data analysis and design
- To focus on CVD reactors
- To study the design aspects of heterogeneous catalytic systems
- To impart the knowledge on mass transfer with reaction in process catalysts

Outcome:

- Enables the students to understand the design aspects of non isothermal and adiabatic reactors
- Enables the students to on heterogeneous data analysis and design aspects of heterogeneous catalytic systems
- Able to derive the rate laws for CVD
- Able to develop the rate laws for heterogeneous fluid solid catalyzed reactions under rate limiting situations.

Syllabus:

Review of Fundamentals Rate laws and stiochiometry, reactions with phase change (Scope: Chapter 3 of Fogler) Least squares Analysis of rate data: differential reactors: Laboratory reactors (Scope: sections 5.4 to 5.6 of Fogler) Multiple reactions (Scope: Chapter 9 of Fogler).

Isothermal reactor design (Scope: Chapter 4 of Fogler) Batch reactor, PFR, CSTR design. Pressure drop in reactors, Reversible reactions, unsteady state operation of reactors, Simultaneous reaction and separation

Catalysis and catalytic reactors (Scope: Chapter 6 of Fogler) Steps in catalytic reaction: derivation of rate laws, design for gas-solid reactions, heterogeneous data analysis and design; Chemical vapour deposition, catalyst reactivation, moving bed reactions.

Diffusion and reaction in process catalysts (Scope: Chapter 11 of Fogler).

Diffusion and reaction in spherical catalyst.

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Internal effectiveness factor, falsified kinetics; estimation of diffusion and reaction limited regimes. Mass transfer and reaction in packed bed. Determination of limiting situations from reaction data, CVD reactors.

Non-isothermal reactor design (Scope: Chapter 8 of Fogler), Energy Balance, equilibrium conversion under adiabatic conditions unsteady state operation, multiple steady states.

Learning outcomes:

- Express important concepts in reaction kinetics and classify reactions according to different properties.
- Calculate the reaction rate constant and reaction activation energy using Least squares Analysis of rate data
- Explain
- Explain the criteria used to evaluate the laboratory reactors and solve problems related to multiple reactions
- develop performance equations for different types of reactors using mass balances
- Design different reactors and explains the Simultaneous reaction and separation.
- Develop the rate laws for heterogeneous fluid solid catalyzed reactions under rate limiting situations.
- Develop the expression for concentration profile and effectiveness factor for first order reaction in a spherical pore of a catalyst.
- Explain different mechanisms postulated for adsorption and surface reaction in catalytic reactions.
- Explain the mass transfer and reaction in a packed bed.
- Do design calculations for non isothermal and adiabatic reactors
- Investigate the effect of temperature on reactor design and reaction parameters.
- Calculates the multiple steady states for MFR type reactors

Textbook:

Fogler. H.S: Elements for Chemical Reaction Engineering 2nd Edition, Prentice Hall, New Delhi, 1992.

Reference:

Smith J.M: 'Chemical Engineering Kinetics' 3rd Edition, McGraw Hill, 1981.

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CHEM-1.1.2: Transport Phenomena
(Common for Chemical, MPE, CACE & IPCE)

Objectives:

- To be able to analyze various transport processes with understanding of solution approximation methods and their limitations.

Outcomes:

- Ability to understand the chemical and physical transport processes and their mechanism.
- Ability to do heat, mass and momentum transfer analysis.
- Ability to analyze industrial problems along with relevant approximations and boundary conditions.
- Ability to develop steady and time dependent solutions along with their limitations.

Syllabus:

Unit 1: Momentum Transport

1.1 The Equations of change for isothermal systems.
1.2 Velocity distributions with more than one independent variable.
1.3 Velocity distributions in turbulent flow.
1.4 Inter phase transport in isothermal systems.

At the end of the course, the student will be able to:

- Perform momentum balance for a given system at microscopic scale.
- Solve the governing equations to obtain velocity profile.
- Solve the unsteady state momentum equation to obtain velocity profiles
- Understand the momentum transport under turbulent conditions and can be able to find out the friction factor or drag coefficient for a fluid flow system

Unit 2: Energy Transport

1.1 The Equations of change for non – isothermal systems.
1.2 Temperature distributions with more than one independent variable.
1.3 Temperature distributions in turbulent flow
1.4 Inter phase transport in non isothermal systems.

At the end of the course, the student will be able to:

- Perform energy balance for a given system at microscopic scale.
- Solve the governing equations to obtain temperature profiles at steady state and unsteady state condition.
- Understand the energy transport under turbulent flow conditions and can be able to find out the heat transfer coefficient.

Unit 3: Mass Transport

1.1 The Equations of Change for multi component systems.
1.2 Concentration distribution with more than one independent variable.
1.3 Concentration distribution in turbulent flow.

At the end of the course, the student will be able to:

- Perform the mass balance for a given system at microscopic scale and can be able to solve the governing equation to obtain concentration profiles.
- Solve the unsteady state mass balanceequation to obtain concentration profiles
- Understand the mass transport phenomena under turbulent flow conditions.

Textbook:

"Transport phenomena" R. Byron Bird, Warren E. Stewart and E.N. Light foot, Wiley & Sons, Inc., New York.

Reference Books:

1."Fundamentals of Momentum, Heat and Mass Transfer" James R. Welty, Charles E. Wicks and Robert E. Wilson, John Wiley & Sons, Inc., New York.

2. "Boundary – Layer Theory", Dr.H.Sehlichting, McGraw – Hill Book Company, New York.

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CHEM-1.1.3: Elective – I

CHEM- 1.1.3 A - Elective-I (Petroleum Refinery Engineering-I)

Objective: The objective of this course is to provide with:

Basic concepts of petroleum refinery engineering, refinery process, products, specifications, test methods and design of equipment.

Outcomes: The student will be able to:

- Understand the formation and composition of petroleum and classify important refinery products and their properties.
- Analyze the fractionation of petroleum, treatment techniques, thermal and catalytic process and design of distillation towers.

Syllabus:

Origin, formation and composition of petroleum: Origin and formation of petroleum, Reserves and deposits of world, Indian petroleum industry, Composition of petroleum.

Petroleum processing data: Evaluation of petroleum, thermal properties of petroleum fractions, important products and properties, test methods.

Learning outcomes:

- Understand the origin and composition of petroleum, deposits of world.
- Classify the petroleum products and test methods.

Fractionation of petroleum: Dehydration and desalting of crudes, heating of crude-pipe still heaters, distillation of petroleum, blending of gasoline.

Learning outcomes:

- Explain the dehydration and desalting of crudes.
- Analyzing crude pipe still heaters and blending of gasoline.

Treatment techniques: Treatment of gasoline, kerosine, lubes, and wax purification.

Learning outcomes:

- Discuss the treatment of gasoline, kerosine and lubes.
- Explain the wax purification.

Thermal and catalytic processes: Cracking, catalytic cracking, catalytic reforming, coking, alkylation process.

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Learning outcomes:

- Explain the catalytic cracking and catalytic reforming process.
- Explain the coking and alkylation process.

Design of atmospheric distillation and vacuum distillation towers.

Learning outcomes:

- Design of atmospheric distillation column.
- Design of vacuum distillation column.

Text book: Petroleum refinery engineering by Nelson.
Reference Books: 1.Modern petroleum refining process by B.K.Bhaskara Rao.
2.Petroleum refining technology by Dr.Ram Prasad.

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CHEM- 1.1.3 B - Elective-I (Process Dynamics and Control-I)

Objectives:

The student is equipped with the analytical tools that are required in the actual design and analysis of distillation control systems. Further this subject provides a unified treatment of steady-state and control aspects of distillation operations.

Outcome:

1. The student know different techniques to formulate and solve binary and multicomponent distillation problems along with case studies
2. Knowing of those variables that affect the composition of the products
3. Dynamic mathematical tools used in controller tuning and process-identification techniques would be known.
4. Design and application of advanced control concepts to distillation would be thoroughly understood.

Syllabus:

Unit 1 : Overview of steady state distillation concepts.

Unit 2 : Distillation control concept - Controlled variables in distillation - Basis for distillation control strategies - Dynamic Modelling & Simulation.

Unit 3 : Process identification - Frequency response and Controller tuning - Pairing and interaction in distillation.

Unit 4 : Feed forward control - Cascade and parallel cascade control - Dead time compensation.

Unit 5 : Inferential control and model algorithmic control.

Textbook :

Distillation Dynamic and Control - Pradeep B., Deshpande, ISA, Tata McGraw Hill Co. Ltd.

Reference:

Design of Distillation Column Control Systems -Luyben and Shunta ISA. Tata McGraw Hill Co.

Learning Outcomes

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UNIT-I

1. After completing this unit, the students will be able to choose a key component for the calculations involved in the multicomponent distillation operation.
2. At the end of this unit, the students can predict vapor-liquid equilibrium data by using a suitable excess Gibbs free energy equation.

UNIT-II

1. The students will be able to identify the variables that would be useful for controlling the distillation columns.
2. For effective control of distillation columns best control strategy would be selected among various alternatives.

UNIT-III

1. By studying this unit, the students will be able to predict the transfer function from response of different forcing functions.
2. Controller tuning parameters can be predicted for any given control system after completion of this unit.

UNIT-IV

1. Selection of suitable advanced control action would be possible for a given situation once the student completes learning this unit.
2. The students become familiar in compensating the dead time that exists in the distillation columns.

UNIT-V

1. The student can estimate the response of a distillation column by applying internal model control.
2. Application of appropriate mathematical models can be examined for superior control of distillation columns.

Textbook :

Distillation Dynamic and Control - Pradeep B., Deshpande, ISA, Tata McGraw Hill Co. Ltd.

Reference:

Design of Distillation Column Control Systems -Luyben and Shunta ISA. Tata McGraw Hill Co.

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CHEM- 1.1.3 C - Elective-I (Electrochemical Engineering-I)

OBJECTIVES:

- To enable the basic principles of electrochemistry, electrochemical devices, electro active materials used in such devices, and case studies of batteries.

- To enable the clean energy needs and demands especially in the electrochemical power generation sector; and to become educators, practicing engineers, and national leaders in electrochemical energy conversion and storage.

- To enable the integrated skills in fundamentals of electrochemistry (e.g.; chemistry, physics, mathematics, thermodynamics, and chemical kinetics) and electrochemical engineering applications (batteries, solar, flow and fuel cells, electrochemical synthesis and corrosion) to ensure successful career opportunities and growth within electrochemical power generation industries and academia.

- To enable the students in energy related programs such as clean power generation and future green technologies.

OUTCOMES:

- The student would know how to solve the problems relating to the production, storage, distribution and utilization of electrochemical energy and the associated environmental issues. And he would know integration of electrochemical principles and materials science for application in modern electrochemical devices.

- The student would know design and conduct experiments, acquire data, analyze, interpret data, solve practical and complex problems on a variety of electrochemical devices such as batteries, solar cells, flow and fuel cells and integrate the professional, ethical, social and environmental factors in electrochemical engineering and understand the impact of these factors on global energy issues.

Syllabus:

Introduction:

Unit I : Basic Concept: Mechanism of Electrolysis, Laws of Electrolysis, Curent and Voltage Efficiency - Electrolytic dissociation, Coulometers, Ionic conduction. Electrolytic conductivity, Absolute ionic velocities, ionic mobilities, Transference Nos. Modern Ionic

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Theory, Ionic activity Degree of dissociation. Ionic Atmosphere Time of relaxation and relaxation effect, Electrophoretic effect - Debye - Huckel Onsager equation of conductance (Derivation is not required) and its validity.

- Able to understand the concept and applications of Laws of Electrolysis.
- Able to understand the importance and construction of Coulometers.
- Able to understand about Transference Nos.
- Able to understand Degree of dissociation.

Unit II: Thermodynamics I: Chemical Potential and Free Energy changes. Cell and Electrode potentials. Thermodynamics of Electrode potentials - Nernst Equation. Equilibrium Constant, Arbitrary Zero of potential, EMF series and their limitations Activity Coefficient of and their evaluation, Liquid Junction potentials, Concentration Cells - Reference Electrodes.

- Able to understand the concept of Chemical Potential and Free Energy changes.
- Able to understand how to calculate cell electrode potential.
- Able to understand the application of Nernst Equation.
- Able to understand how to measure Junction potential.

Unit III : Thermodynamics II : Electrode Kinetics, Role of Interface, Electric Double Layer and its capacitance - Irreversible Electrode processes - Irreversibility, Tates of Electrode Processes. Electrode Kinetics Model, Cathodic Hydrogen evolution, Depolarisation - Overpotential, Tafel Equation, Ohmic or resistance Over potential, Concentration overpotential, Oxygen Evolution reaction and Decompostion potential, Ionic Transport by Migration, Diffusion and Convection - Mass transfer.

- Able to understand Electric Double Layer theory.
- Able to understand the concepts of Depolarisation and Overpotential.
- Able to understand importance of Tafel Equation.

Unit IV : Kenetics of Corrosion Processes and Evans Diagrams : Electrokinetic phenomenon - Straming potential, zeta potential and Electro - Osmosis, Electrophoresis, Dorn Effect.

Measurements and Systems Analysis : Conductivity measurements - Conductometric analysis - Titrations, Measurements of pH, potential - potentiometric titrations, Polarography Electrogravimetry, Coulometry. Current Distribution in a cell. Rotating Disc Electrode, Rotating Cylinder electrode, Rough Surface Electrode Limiting Current Technique.

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- Able to understand the importance of Evans Diagrams.
- Able to understand the concepts of Osmosis and Electrophoresis.
- Able to understand the importance of Conductometric analysis – Titrations.
- Able to understand about potentiometric titrations.

Unit-V: Potential relations in corrosion cells potentials, pH diagrams in corrosion.

Corrosion theory : Manifestation of corrosion, bases of electrochemical corrosion, amount and intensity of corrosion, Eight forms of corrosion : Uniform attack, Galavanic corrosion, crevice corrosion,Pitting, inter granular corrosion. Selective leaching, stress corrosion cracking. Conditions leading to pitting attack., environmental factors, hydrogen damage. Corrosion inhibition and prevention : Domestic water supplies, recirculating water systems, corrosion inhibitors, Inhibitors for acid pickling, vapor phase inhibitors. Coatings and paits: Phosphating, Protective metal coatings; cathodic protection and corrosion of buried structures.

- Able to understand the different forms of corrosion.
- Able to understand the preventive techniques of corrosion.
- Able to understand the concepts of Protective metal coatings.
- Able to understand the application of cathodic protection of buried structures.

Textbooks:

1. An Introduction to Electrochemistry by Samuel Glasstone, D. Van Nostrand Company Inc princeton, Affiliated East-West press Pvt. Ltd.
2. Electrochemistry - Principles and Applications by Edmund C. Fotter Oliver Hume Press Ltd., London.

Reference Books:

1. Electrochemical Engineering, Principles, by Geofferey Prentice, The Johns Hopkins University, Prentice Hall, Englewood Cliffs, New Jersy, 07632.
2. Electrochemistry - Bookris and A.K.Reddy.
3. Electrochemical Engineering by C.L.Mantell.
4. Principles of Electrochemical Engineering by L.W.Shemilt.
5. Chemical Engineering Development Centre, Indian Institute of Technology, Madras 600 036.
6. Fontanna and Grene ‘Corrosion Engineering’.

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CHEM-1.1.4: Elective –II

CHEM-1.1.4 A - Elective-II (Corrosion Engineering-I)

Common for M.Tech (Chemical, MPE, IPCE, CACE & Biotechnology)

Objectives : The main objectives are to provide:

1. Basic aspects of electrochemistry relevant to corrosion phenomena,
2. Importance and forms of corrosion.
3. Knowledge on corrosion rate expressions and measurement techniques.
4. Knowledge on factors influencing corrosion of iron and steel exposed to atmospheric, soil and aqueous medium.
5. Basic knowledge on remedial measures for corrosion.

Outcome: At the end of the course, the student will be able to

1. Acquires knowledge on basic principles of electrochemistry, importance of corrosion.
2. Predict whether corrosion will occur for a particular environment.
3. Estimate corrosion rates and analyze.
4. Identify the type of corrosion and propose viable remedial measures.

Syllabus:

Basic Concepts and Outlines of Electrochemistry: Fundamentals of Electrochemical reactions, Faraday's Laws Electrolytic and ionic conductance, ionic mobility's, Transport Nos. Galvanic Cell and Electrolytic cells.

Definition and importance of corrosion, Dry cell, analogy, Corrosion Cells, Types of Corrosion Cells- a) Dissimilar electrode cells b) Concentration cells such as a salt concentration cells, differential aeration cells c) differential Temperature cells. Corrosion Rate Expresions - mdd, ipy, cpy, mpy, etc.

LO1: Choose a specific cell for a given situation
LO2: Identify the type of corrosion cell that will form in that particular environment

Corrosion Tendency and Electrode Potentials: Free Energy changes, Development of Nernst Equation for calculation of Half-cell potentials, Hydrogen electrode, Spontaneity of a reaction, Reversible cells and potentials – convention of Sign and calculations of EMF from standard Equilibrium potentials., EMF Series and Galvanic series, Reference Half Cells – Calomel, Silver-Silver Chloride and Saturated Copper-Copper Sulphate Half Cells. Pourbaix Diagram for Iron, Aluminum and magnesium, limitations of pourbaix diagrams.

LO3: Predict the tendency of corrosion to occur
LO4: Identify the corrosion zones based on pH of media

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Polarization and Corrosion Rates: Polarization and a Polarized Cell, Causes of Polarization – Concentration Polarization, Activation Polarization and IR drop. Hydrogen Over potentials, combined polarization and Mixed potential theory. Tafel Slopes and Tafel Equation. Graphical method of expressing Corrosion Reactions (Polarization diagrams/Evans diagrams), Derivation of Stern-Geary Equation, Influence of Polarization on Corrosion rates.

LO5: Derive the equations for estimating corrosion rates
LO6: Evaluate and Analyze data for corrosion rates

Passivity: Characteristics of Passivation, Flade potential, behavior of passivators, transpasivity, Theories on Passivity.

Forms of Corrosion: Uniform attack, Galvanic Corrosion, Crevice Corrosion, Pitting, Intergranular Corrosion, Selective Leaching, Erosion Corrosion and Stress Corrosion. Hydrogen damage. Factors influencing, mechanisms and prevention techniques for all forms of corrosion. Calculation of Corrosion rates using weight lost method and Polarization data. Electrochemical Impedance Spectroscopy.

Effect of Dissolved Oxygen (Air saturated Water, High Partial Pressure of Oxygen and Anaerobic bacteria), Temperature, pH, Galvanic coupling, velocity, dissolved salts concentration. Wet and dry corrosion.

LO7: Identify the type of corrosion
LO8: Recommend proper remedial measures

Textbooks :

1. Corrosion and Corrosion Control by Herbert, H. Uhlig John Wiley and Sons Inc., New York.
2. Corrosion Engineering by Mars F Fontana, McGraw Hill.
3. An Introduction to Electrochemistry by Samuel Glass stone, Affiliated East West Press Pvt. Ltd.,

Reference Books :

1. Corrrosion Volumes 1 & 2 by L.L. Shrier, Newnes - Butter-worths, London.

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CHEM- 1.1.4 B - Elective-II (Energy Engineering-I)
Common for M.Tech (Chemical, MPE, IPCE, CACE & Biotechnology)

Objectives:

To lean overview of solar radiation and it's potential for collection to meet the energy needs of mankind and potential for solar energy option. To learn measuring techniques of solar radiation and its compilation.

To learn various design and operational aspects of solar energy collection and storage.

To learn the design and operation of solar energy appliances like liquid flat plate collectors, Solar Air Heaters, Thermal energy storage, Thermal energy storage, Solar Pond, Solar thermal power generation.

To learn theory and application of Photovoltaic cells

Outcome:

The student learns collection and design of various kinds of equipment operated on solar energy. The student learns principles and practice of Photo voltaic cells.

Syllabus:

The Solar Energy option

Thermal conversion – collection and storage Thermal applications – photovoltaic conversion – wind energy – Energy from Bio – mass – ocean thermal energy conversion.

Solar Radiation

Solar Radiation outside the earths – atmosphere Solar radiation at the Earth's surface – Instruments for measuring Solar Radiation – Solar Radiation data – Solar Radiation Geometry Empirical equations for predicting the availability of Solar Radiation – Solar radiation on tilted surface.

Liquid flat – Plate Collectors

Components of liquid flat plate – various types of collectors – Performance Analysis – Transmissivity – Absorptivity product – Overall loss coefficients and heat Transfer correlations – Collector efficiency heat removal factors – effect of various parameters on performance. Transient Analysis – Testing procedures.

Solar Air Heaters

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Various types of solar Heaters – Performance Analysis of a conventional Air Heater – Testing procedures – Concentrating collectors – various types of concentrating collectors cylindrical and parabolic collectors – General receiver collectors.

Thermal energy storage

Sensible heat storage – Latent heat storage – Thermochemical storage

Solar Pond

Description – Performance analysis – Experimental studies – Operational problems.

Solar Air Conditioning and Refrigeration

Heat pump cycle – Coefficient of performance of the heat pumps – solar air-conditioning with absorption – Refrigeration system (Ammonia water and lithium bromide – water systems).

Solar thermal power generation

Thermal and direct electricity generation – Major sub-stations of a solar thermal power plant, Examples of installed systems – Concentration ratio. Temperature and efficiency concepts – Solar farm and tower – Economics.

Photovoltaic Energy Conversion

Photovoltaic Energy Conversion Fundamentals – band theory of solids – Physical processes in a solar cell – Solar cell with light incidence – Solar cell module – Silicon Solar Cells – Copper Sulphate / Cadmium sulphide Solar Cells.(Banasal et at.,chapters 9;Taylor, chapters 6, pages 256-298.

Text Books:

1. Solar Energy: Principles of thermal collection and storage by S.P. Sukhatme, Tata McGraw Hill, New Delhi 1984 (Chapters 2 to 8)
2. Renewable energy sources and conversion technology by N. K. Bansal, M. Kleemann, Michael Mcliss, 1990 (Chapters 2 – 9).

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CHEM- 1.1.4 C - Elective-II (Reaction Engineering-I)
Common for M.Tech (Chemical, MPE, IPCE, CACE & Biotechnology)

Unit I : (Scope : J.M. Smith : Chapter 7): Heterogeneous Processes, catalysis, and absorption: Global Rates of Reaction - Types of Heterogeneous Reactions - The nature of catalytic Reactions - The Mechanism of catalytic Reactions - Surface Chemistry and Absorption - Absorption Isotherms - Rates of Absorption.

Unit II (Scope : J. M. Smith: Chapter 8 : Solid Catalysts: Determination of surface area - Void Volume and solid density - Fore volume distribution - Theories of Heterogeneous Catalysis - Classification of catalysts - Catalyst Preparation - Promoters and Inhibitors Catalyst Deactivation (Poisoning).

Unit III: (Scope: J.M. Smith : Chapter 9): Rate equations for fluid - Solid Catalytic Reactions: Rates of adsorption, Desorption, Surface Reaction - Rate equations in terms of Fluid phase concentrations at the catalyst surface - Qualitative analysis of rate equation - Quantitative inter pretation of Kinetic data - Redox Rate equations.

Unit IV: (Scope : Octave Levenspiel : Chapter 15) : Deactivating Catalysts : Mechanism of Catalyst Deactivation - The ratre of equation - The rate of equation from experiment - Batch - solids: Determining the rate for Independent Deactivation Batch - solids : Determining the rate of parellel, series or side - by - side Deactivation - Flowing solids experimental Reactors - Finding the Mechanism of Decay from experiment Design.

Unit V: (Scope : J. M. Smith : Chapter 10) : External transport Processes in Heterogeneous Reactions: Fixed bed reactors - The effect of physical processes on observed rate of reaction - Mass and Heat transfer coefficients (fluid particle) in packed beds - Quantitative treatment of external transport effects - Stable operating conditions - Effect of external transport Processes on selectivity.

Fluidised bed reactors - Particle - fluid Mass and Heat transfer Slurry Reactors - Mass transfer coefficients: Gas bubble to liquid (K_l) - Mass transfer coefficients: Liquid to particle (K_c) - The effect of mass - transfer on observed rates Trickle - Bed reactors - mass transfer coefficients: Gas to liquid ($K_l a_g$) - Liquid to particle ($k_c a_c$) - Calculation of global rate.

Text Books:

1. Smith. J.M., " Chemical Engineering Kinetics", McGraw Hill book Company, New Delhi (Third Edition) 1981.
2. Octave Levenspiel, " Chemical Reaction Engineering" , Wiley Eastern Limited - Second Edition - 1972.

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Reference Books :

1. Thomas, J.M. And Thomas, W.J. " Introduction to the Principles of Heterogeneous Catalysis". Academic Press Inc., New York 1967.
2. Carbnerry, James, J., " Chemical and Catalytjic Reaction - Engineering", McGraw - Hill, Engineering Series.

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CHEM 1.1.5: RESEARCH METHODOLOGY AND IPR
Common for M.Tech (Chemical, MPE, IPCE, CACE & Biotechnology)

Unit 1: Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations

Unit 2: Effective literature studies approaches, analysis, Plagiarism, Research ethics,

Unit 3: Effective technical writing, how to write report, Paper, Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

Unit 4: Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

Unit 5: Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.

Unit 6: New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

References:

1. Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science
2. & engineering students'"
3. Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction"
4. Ranjit Kumar, 2nd Edition , "Research Methodology: A Step by Step Guide for beginners"
5. Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd ,2007.
6. Mayall , "Industrial Design", McGraw Hill, 1992.
7. Niebel , "Product Design", McGraw Hill, 1974.
8. Asimov , "Introduction to Design", Prentice Hall, 1962.

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9. Robert P. Merges, Peter S. Menell, Mark A. Lemley, " Intellectual Property in New
10. Technological Age", 2016.

11. T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008

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CHEM 1.1.6 A: Audit Course-1 (YOGA FOR WORKING PROFESSIONALS)

Common for M.Tech (Chemical, MPE, IPCE, CACE & Biotechnology)

Course objectives:

1. To make the student understand various practices of yoga and yoga diet.
2. To make the student be familiar with various asanas and other associated practices.
3. To make the student appraise the holistic benefits of yoga
4. To make the student identify a therapeutic solution for common health issues.
5. To make the student experience the pranahuti aided meditation.

Course outcomes:

1. The students will discover the importance of yoga for leading a disciplined way of life.
2. The students would improve their wellness by adapting various yogic practices in their day to day life.
3. The students would perceive the holistic benefits of yoga
4. The students can judge the causes of common diseases and can recommend therapeutic solutions based on yogic practices
5. The student can compare the placebo meditation and meditation with pranhuti.

Unit-I: Introduction to Yoga

The Origins of Yoga – Definitions - Concepts - Aims and objectives of Yoga - Yoga is a Science and Art - Ideal Practice of Yoga in the new millennium. Streams of Yoga - Karma Yoga - Bhakti Yoga -Jnana Yoga - Raja Yoga (Astanga Yoga) - Hatha Yoga - Yoga and Diet - - Yoga Disciplined way of life. Difference between Yogasanas and Physical Exercises.

Learning outcomes:

1. After completing this unit, the students will be able to recognize the differences between yogic practices and physical exercises.
2. At the end of this unit, the students will be able assess the relevance of yogic practices for holistic wellness in the contemporary times.

Unit-II: Yogasanas with practical

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Loosening the joints- Joint freeing series, Suryanamaskar, Tadasana, Trikonasana, Artha chandrasana, Danurasana, Utkatasana, Dandasana, Pavanamuktasana, Hamsasana, Arthakati chakrasana, Artha chakrasana, Janusirasasana, Vajrasana, Makarasana, Padmasana, Sukhasana, Natrajasana, Savasana. Introduction to Kriyas, Pranayamas, Bandhas and Mudras.

Learning outcomes:

1. The students will be able to demonstrate some selective yogasanas.
2. The students will be able to appraise the importance of allied yogic practices such as pranayama, mudras, bandhas and kriyas.

Unit-III: Physiological benefits of Yoga

Physiological Benefits of Asanas and Pranayama – Chest Cage – Regulation of Breathing – Types of Breathing. Physiological Benefits of Bandhas – Mudras – Kriyas - Meditation – Nadis – Chakras – Kundalini shakti – Psycho-neuro Immunology. Role of Yoga on Psychological Qualities and Psychological Disorders.

Learning outcomes:

1. By studying this unit, the students will be able to value the physiological benefits of yoga practices.
2. The students will be able to support the role of yoga in the treatment of psychological disorders at the end of this chapter.

Unit-IV: Introduction to Yoga Therapy

Essence and Principles of Yoga therapy- Physiology and Pathology in the yoga – Shatra- koshas – doshas- Granthis – Pancha prana – Application of Yoga and its types- Methodology in Yoga Therapy – Factors (Heyam, Hetu, Hanam and Upayam) - Methods (Darsanam, Sparsanam, Prasnam, Nadi, Pariksa) Examination of Vertebra, joints, Muscles, Abdomen and Nervous system and therapeutic applications – Modification of yogic practices for Human Systems- Yogic diet.

Learning outcomes:

1. At the end of the unit, the students become familiar in assessing the health of an individual.
2. After completing this unit, the students can recommend appropriate yoga therapy for health problems faced by an individual.

Unit-V: Meditation

(The student has to maintain a diary to record his observations during meditation. This diary will help him to understand the extent of his progress)

Meaning and Concept of Meditation – Need of meditation- techniques of meditation-Tools of meditation-Advantages of Meditation- Experience of meditation- Obstacles. Sahaj Marg Meditation, Heartfulness movement. Elements of sahaj marg meditation: Prayer, cleaning, sitting, satsang, universal prayer and suggestions. Ten maxims of sahaj marg.

Learning outcomes:

1. The student will be well versed in the benefits of meditation at the end of the unit.
2. The student can experience the difference in normal situation and meditative condition after experiencing pranahuti aided meditation.

Reference books

1. George Feuerstein: The Yoga Tradition (Its history, literature, philosophy and practice).
2. Georg Feuerstein. The Psychology of Yoga: Integrating Eastern and Western Approaches for Understanding the Mind.
3. Swamy Satyananda Saraswathi: Asana, Pranayama, Mudra, Bandha (India: Yoga Publications Trust, Munger, Bihar).
4. Swami Sivananda **:** Practice of Yoga (The Divine Life Society, Shivananda Nagar.P.O.,U.P. Himalayas, India).
5. Krishna Raman: A Matter of Health (Integration of Yoga and western medicine for prevention and cure) (Chennai East West Books(Madras) Pvt. Ltd.,1998.
6. Bhavanani, A.B. (2011): Application of Yoga Concept in the Health Improvement. In: P.Nikic, ed.
7. Ram Chandra, Complete works or Ram Chandra (Babuji) Vol. I, Sri Ram Chandra Misssion, SPHT, Calcutta.

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CHEM 1.1.6 B- Audit Course -I Organizational Behavior

Common for M.Tech (Chemical, MPE, IPCE, CACE & Biotechnology)

UNIT-I: Organizational Behavior: Concept of Organization - Concept of Organizational Behavior - Nature of Organizational Behavior - Role of Organizational behavior - Disciplines contributing to Organizational Behavior.

UNIT-II: Motivation: Definition - Nature of Motivation - Role of Motivation - Theories of Motivation: Maslow's Need Hierarchy Theory, Herzberg's Motivation Hygiene Theory and McGregor's Theory X and Theory Y.

UNIT –III: Group Dynamics: Meaning - Concept of Group - Types of groups -Formal and Informal groups - Group development - Group cohesiveness and factors affecting group cohesiveness.

UNIT-IV: Leadership: Concept of Leadership - Difference between Leadership and Management - Importance of Leadership - Leadership styles: Autocratic leadership, Participative leadership and Free Rein leadership.

UNIT-V: Communication: Meaning - Communication Process - Forms of communication: Oral, Written and Non- Verbal communication - Direction of communication: Downward, Upward and Horizontal communication.

UNIT-VI: Organizational conflicts: Concept of conflict - Reasons for conflict - Types of Conflict: Intrapersonal conflict, Interpersonal conflict, Intragroup conflict, Intergroup conflict, Inter organizational conflict - Conflict management.

UNIT –VII: Organizational Change: Nature - Factors in Organizational change -Planned change: Process of planned change - Resistance to change: Factors in resistance to change - Overcoming resistance to change.

Text Books.

1.L.M.Prasad: Organizational Behavior, Sultan Chand & Sons, New Delhi -110002

2.K. Aswathappa: Organizational Behavior, Himalaya Publishing House, New Delhi

Reference Books.

1. Stephen Robbins: Organizational Behavior, Pearsons Education, New Delhi.

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II SEMESTER
CHEM –1.2.1: COMPUTER AIDED DESIGN
(Common for Chemical Engineering & CACE)

The objectives of this course are to provide the student with:

- a basic understanding of the fundamentals of executive program, executive program aided simulation, unit computations, information flow diagram, encoding of information flow diagram, simulation of a simple plant, applications of simulation
- knowledge to write algorithm and programs for various fluid flow problems, pressure drop in two phase flow, pipeline network calculations
- knowledge to write algorithm and programs for rating and design calculations heat exchanger, condenser, reboiler, flash calculations, distillation column, gas absorption column, crosscurrent and counter current extraction, analysis of data in a reactor, extent of reaction, ideal reactors, semibatch reactor, packed bed reactor and fluidized bed reactor

Outcome:

- Enables students to learn the basics of computer aided design, executive program aided simulation and its applications
- Students will be able to write/develop unit computations (programs) for fluid flow, mass transfer, heat transfer and reaction engineering problems

Syllabus:

Unit I

Introduction on simulation and importance of simulation for chemical process industries Introduction to computer aided design- executive program. coding of chemical process flow chart. Information flow diagram, unit computations, developing a description of information flow diagram, information flow diagram to numerical form, planning calculations, finding recycles, planning calculations for recycle set.

Unit II

Mass transfer operations: introduction, distillation- simple binary distillation, Multicomponent flash calculations, multi component stage wise calculations, Gas absorption- absorption and stripping in plate columns, absorption in packed columns, Liquid extraction- single stage contact, cross current extraction, counter current extraction

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Unit III

Flow of fluids in pipes: Introduction, flow of Newtonian fluid in a pipe- incompressible fluid flow, sizing of pipes, Pressure drop in compressible fluid flow, flow of non Newtonian fluids- Bingham plastic fluid, Power law fluid, generalized Reynolds number, Sizing of pipes for non Newtonian fluid How, Pipe network calculations, two phase flow systems- gas liquid flow, solid liquid flow, gas solid flow.

Unit IV

Heat transfer: Introduction, shell and tube exchangers without phase change- tube side heat transfer coefficients, shell side heat transfer coefficients, pressure drop in shell and tube heat exchanger, condensers, reboilers

Unit V

Chemical reaction Engineering: Introduction, extent of reaction, chemical reaction equilibrium- independence of reactions, calculation of chemical equilibrium, Analysis of rate data - Integral method, differential method, nonelementary reactions, temperature dependence of rate constant, Ideal reactors- batch reactor, continuous stirred tank reactor, plug flow reactor, semi batch reactor, Temperature effects in homogeneous reactors- ideal batch reactor, CSTR, PFR, Heterogeneous system- analysis of rate data, fixed bed reactor, catalyst deactivation.

Prescribed book:

1. Chemical Process calculations by Raghu Raman, Elsevier applied science publishers,

London-New York

2, Simulation of sulphuric acid plant by Crowe

3. Product and process design principles- synthesis, analysis and evaluation by Warren

Sieder, J.D. Sieder, Daniel R. Lewin

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CHEM-1.2.2: Process Dynamics & Control
(Common for MPE, CACE & IPCE)

Objectives :

The main purpose of teaching Process Dynamics & Control for first year postgraduate students is to take the student from basic mathematics to a variety of design applications in a clear, concise manner. This course is focused on the use of the digital computer in complex problem solving and in process control instrumentation. For chemical engineering problem solving students need more advanced mathematical preparation like partial differential equations, linear algebra and Fourier series all are introduced in this course.

Outcome:

- Able to know the sampled data control systems consists of sampling and advanced mathematical model Z- transforms.
- Able to describe the process in which the flow of the signals is interrupted periodically like in chromatograph.
- Able to calculate the open loop response of a sampled data system and can develop a pulse transfer function that is the counterpart of the transfer function for continuous systems.
- Able to know the sophisticated instruments used for the analysis of water and air pollutants, The student should have knowledge to design the equipment used for the abatement of these pollutants.
- In a position to modernize the solid waste management and the student must be in a position to get awareness on accidents that are occurring in industries during handling, storage, and manufacturing of chemicals, remedial measures to arrest the accidents immediately.

Syllabus:

Unit-1

Review of time domain, Laplace domain and frequency domain dynamics of process and control system.

Learning outcomes

- Able to know the sampled data control systems consists of sampling and
- Able to solve the problems related to Laplace domain and frequency domain dynamics of process and control system.

Unit-2

Sampled data control system – sampling and Z–Transforms , open loop and closed loop response, Stability.

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Learning outcomes

- Able to solve the problems related toSampled data control system – sampling and Z–Transforms ,
- Able to calculate the open loop response of a sampled data system and stability

Unit-3

State space methods – representation of physical systems – transfer function matrix – Multivariable systems – Analysis and control.

Learning outcomes

- Able to solve the problems related toState space methods – representation of physical systems and Student can develop a pulse transfer function that is the counterpart of the transfer function for continuous systems.
- Able to solve the Design Multivariable control systems – Analysis and control.The student should have knowledge to design the equipment used for the abatement of these process control systems.

Unit-4

Non linear control –examples of non linear systems – Methods of phase plane analysis.

Learning outcomes

- Able to solve the problems related toNon linear control systems
- Able to solve the problems related toexamples of non linear systems and also develops Methods of phase plane analysis.

Unit-5

Control of heat exchangers, distillation columns and Chemical Reactors.

Learning outcomes

- Able to solve the problems related toControl of heat exchangers, distillation columns and
- Able to solve the problems related toChemical Reactors.

Textbooks:

1. Process system Analysis and control, 2nd edition, Donald R Coughanower and Koppel.
2. Automatic process Control by Peter Harriot.
3. Process Modeling, Simulation and control for Chemical Engineers by W.L. Luyben.

CHEM- 1.2.3 - ADVANCED MASS TRANSFER

Objectives:

- To develop skills in the process design of mass transfer operations
- To understand problems involving mass transfer using the principles of material and energy balances.

Outcomes:

- Ability to design process equipment for various mass transfer operations.
- Ability to use equations of change for multi-component systems.
- Ability to solve problems of mass transfer in laminar and turbulent regimes.
- Ability to solve problems of interphase transport in non-isothermal systems.

Syllabus:

Chapter 1: Flux Definition

- Mass and molar transport by convection
- Summary of mass and molar fluxes
- Fick's law

Chapter 2: Differential Equations of Mass transfer

- Differential equation for mass transfer
- Boundary conditions

Chapter 3: Molecular diffusivities

- Diffusivities in gases
- Diffusivities in liquids

Chapter 4: Molecular diffusion

- Steady state molecular diffusion
- Steady-State Equimolal counter diffusion in gases
- Steady state Equimolal unidirectional diffusion in gases
- Molar diffusion in liquids
- Diffusion through a stagnant gas film
- Diffusion with a moving interface
- Diffusion through a Nonisothermal Spherical film
- Diffusion with a Heterogeneous Chemical reaction

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- Diffusion with a slow Heterogeneous Chemical reaction
- Diffusion with a homogeneous Chemical reaction
- Unsteady state diffusion in a sphere
- Unsteady state diffusion in a slab
- Unsteady state diffusion in a Cylinder

Chapter 5: Mass Transfer coefficients

- Individual Mass transfer coefficients
- Overall Mass Transfer coefficients
- Mechanism of Mass transfer
- The two-film theory
- The penetration theory
- The theory of penetration with Random surface renewal

Chapter 6: Mass transfer in Laminar Flow

- Mass transfer in the laminar boundary layer on a flat plate (Integral Solution)
- Mass transfer in laminar Natural convection on a vertical plate
- Mass transfer in a falling liquid film in a laminar flow
    - Mass transfer between a gas phase and a falling liquid film (gas absorption)
    - Mass transfer between an inclined plate and a falling liquid film (Solid dissolution)
    - Gas absorption with rapid reaction

Chapter 7: Mass Transfer in turbulent flow

- Mass transfer in the turbulent boundary layer on a flat plate
- Mass transfer in turbulent Natural convectionon a vertical plate
- Mass transfer between inclined plate and a falling liquid film in turbulent flow
- Anologies between momentum, heat and mass transfer
    - Reynolds analogy
    - Prandtl analogy
    - Von Karman analogy
    - Analogies in terms of j factor

Text Books:

1. A H P Skelland, Diffusional Mass transfer, John Wiley and Sons (1974)

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Reference Books:

1. R B Bird, W E Steward and E N Lightfoot, Transport Phenomena, 2nd Ed., John Wiley and Sons (2002)
2. J R Welty, C E Wicks, R E Wilson and G. Rorrer, Fundamentals of Momentum, Heat and Mass transfer, 4th Ed., John Wiley and Sons (2001)

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CHEM-1.2.4 - Elective-III

CHEM-1.2.4 A – ELECTIVE-III (Petroleum Refinery Engg-II)

Objective: The objective of this course is to provide with the**:**

- Production process for the manufacture of C1 to Aromatic Compounds.
- Design aspects for designing of various equipment used in the process.

Outcomes: The student will be able to:

- Understand the process and mechanism of various production process of C1 to Aromatic compounds.
- Design various equipment used in the production process.

Syllabus:

Petrochemical industry in India, Raw materials for petrochemicals, refinery process for petrochemical feed stocks, pyrolysis for petrochemical feed stocks, separation of hydrocarbons.

Learning outcomes:

- Choose various petrochemical feed stocks for manufacture of petrochemical compounds.
- Discuss various refining process for the manufacture of petrochemical feed stocks.

Petrochemicals from C1 fractions: Synthesis gas, Methanol, Formaldehyde, Chloromethanes, Hydrogen cyanide, Methyl amines.

Petrochemicals from C2 fractions: Polyethylene, Ethanol, Ethylene Oxide, Acetaldehyde, Ethyl Benzene, 1-2 dichloroethane, Vinylchloride, Vinylacetate, Ethanol amines.

Learning outcomes:

- Design and evaluate a process for the manufacture of C_1 fractions.
- Design and evaluate a process for the manufacture of C_2 fractions.

Petrochemicals from C3 fractions: Isopropanol, Acetone, Propylene oxide, Acrylonitrile, Cumene, Isoprene, Oligomers and co-oligomers of Propylene.

Petrochemicals from C4 fractions: Butadiene, Diisobutene, Butanol, Methacrylic acid, Maleic anhydride.

Learning outcomes:

- Design and evaluate a process for the manufacture of C_3 fractions.
- Design and evaluate a process for the manufacture of C_4 compounds.

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Petrochemicals from Aromatic compounds: Production and separation of aromatics, Aniline, Phenol, Maleic anhydride, Toluene diisocynate, Phthalic anhydride, Dimethyl terephthalate.

Learning outcomes:

Design a process for the production of aromatics.
Develop a process for the separation of aromatics.

Design of petrochemical equipment: Pyrolysis furnace, pyrolysis reactor, super fractionator, fixed bed reactor, multiphase reactor.

Learning outcomes:

Design of pyrolysis furnace, pyrolysis reactor and super fractinator.
Design of fixed bed reactor, multiphase reactor.

Text Books :

1. Ethylene & its derivations - S.A. Miller
2. Propylene and its derivations - E.G. Hancock.
3. Benzene, Toluene, Xylene and their Derivations. E.G. Hancock.
4. Petrochemicals by B.K.Bhaskara Rao.

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CHEM-1.2.4 B – ELECTIVE-III (Process dynamics and control-II)

Objectives :

The main purpose of teaching Process Dynamics and Control as elective-II for M. tech second year postgraduate students is to make them to understand the unity in outlook that has been lacking in the field of chemical reactor design. The stability viewpoint does in a sense in diverse areas like stirred tank reactor, plug flow reactor. The course in common emerge as qualitative description of the behavior of the respective models, for the stability viewpoint deals with certain structural aspects present in both problems.

Outcome:

- The student should be able to know a brief introduction about the most common chemical reactor models. The subject of steady state multiplicity in stirred tank reactors and develops uniqueness criteria for various cases that may be of interest for design.
- The student should be able to know the interpretation of terms such as steady and stable. The student should have knowledge to explore the implications of the stability concept in dealing with finite disturbances of practical magnitude.
- The student should be in a position to analyze from ordinary differential equation models to partial differential equation models.
- The student should be in a position to understand the steady state multiplicity, local stability, and regional stability are treated for distributed systems.

Syllabus:

Unit I : Mathematical modeling of reactors - Mass and energy balance equations for CSTR,PFTR, TRAM, TRRM, catalyst particle - multiphase models.

Lumped parameter model - steady state multiplicity of a CSTR- Van Herden diagram - criteria for uniqueness of steady state for isothermal and temperature dependent reactors and multiphase systems - design consideration.

Learning outcomes

- The student should be able to know a brief introduction about the most common chemical reactor models and Mathematical modeling of reactors
- The student should have knowledge to explore the subject Lumped parameter model design.

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Unit II : Geometry of dynamics for a lumped parameter model - stable and unstable steady states - phase plane for the CSTR and eigen values - linear second order system and eigen vector - Liapunov stability criterion and Liapunov functions - fundamental linearization theorem - local stability and steady state operating curves for a temperature - dependent reactor.

Learning outcomes

- Able to solve the problems related to Geometry of dynamics for a lumped parameter model Able to calculate the open loop response of a sampled data system and stability
- The student should be in a position to analyze from Liapunov stability criterion and Liapunov functions

Unit III : Region of asymptotic stability and v-function in x-space - Krasovskil's theorem and V-function in f-space.

Learning outcomes

- Able to solve the problems related to Region of asymptotic stability and v-function in x-space and Student can develop a
- Able to solve the Design Krasovskil's theorem and V-function in f-space.The student should be in a position to understand the steady state multiplicity

Unit IV : Steady states in distributed parameter systems - uncoupling the energy and mass balances for TRAM model - Steady state models of a PFTR and parametric sensitivity - Steady state multiplicity of a TRAM and catalyst particle model - uniqueness criteria for fixed bed reactors.

Learning outcomes

- Able to solve the problems related to Steady states in distributed parameter systems -Able to solve the problems related to examples of non linear systems and also develops Methods of phase plane analysis.
- The student should be in a position to understandSteady state models of a PFTR and parametric sensitivity - Steady state multiplicity of a TRAM

Unit V : Local stability of distributed parameter systems - the techniques of linearization of nonlinear differential equations and uncoupling of certain transient conservation equations - applications of these techniques to the cases of catalyst particle and TRAM.

Methods of solution of transient mass and energy balance quations applied to catalyst particle model and TRAM - Galerkin method - Collocation method.

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Learning outcomes

- Able to solve the problems related to Local stability of distributed parameter systems - the techniques of linearization of nonlinear differential equations and uncoupling of certain transient conservation equations - applications of these techniques to the cases of catalyst particle and TRAM.

- Able to solve the problems related to Methods of solution of transient mass and energy balance equations applied to catalyst particle.

Text Book:

Stability of Chemical Reactors by Daniel D. Perlmutter, John Weily and Sons Inc. (New York, (1976).

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CHEM-1.2.4 C- ELECTIVE-III (Electro Chemical Engineering-II)

Objectives: The main objectives are to provide

1. Knowledge on Electroplating, Electroforming, electro refining, electro wining.
2. Knowledge on Electrolysis and Manufacturing process.
3. Knowledge on primary & secondary batteries and fuel

Outcome: At the end of the course, the student will be able to

1. Explain different electrochemical ore beneficiation techniques, electroplating, electro refining and electro winning.
2. Take part in commercial and industrial manufacturing units using electrolysis.
3. Design, test and evaluate batteries e.g. Primary and secondary batteries, charge/discharge cycles, overpotential, battery capacity, state of charge, state of health, impedance.
4. Construct, Compare and test Fuel cells.

Syllabus:

Part –A

Electroplating, Electroforming and Electrophoresis
Electrorefining of metals - Copper, Silver, Gold, Nickel, Lead and Cobalt.
Electrowinning of metals - Copper, Zinc, Cadmium, Chromium and Manganese.

LO1: Appraise various metal extraction procedure by electrochemical means
LO2: Recommend the process conditions

Electrolysis of Alkali Halides and Sulfates - Chlorine and Caustic, Potassium halides, Hydrochloric acid, Fluorine and sodium sulfate.
Manufacture of Hydrogen and Oxygen. Electrolytic Reduction and Oxidation - Persalts, Cuprous oxide, Mercuric oxide, Manganese dioxide and Perchlorates.
Electrolysis of fused Salts - Aluminum, Magnesium, Sodium, Beryllium and Zirconium.

LO3: Choose appropriate manufacturing processes of ionic salts by electrochemical schemes
LO4: Compare different sets of conditions for the manufacture of a given salts

Part –B

Batteries: Classification of cells and batteries, theoretical cell voltage, capacity, energy, electrochemical principles and reactions
Primary batteries: Zinc carbon batteries (Leclanche and Zinc chloride cell system), Magnesium and Aluminum batteries, Alkaline manganese dioxide batteries, Lithium batteries.

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Secondary batteries: Lead acid batteries, nickel cadmium batteries, nickel metal hydride batteries, lithium ion batteries, rechargeable zinc, alkaline, manganese dioxide batteries

LO5: Evaluate the working behavior of different batteries
LO6: Estimate the charge discharge characteristics of a battery

Fuel cells: Molten carbonate fuel cell(MCFC), phosphoric acid fuel cell(PAFC), Solid oxide fuel cell (SOFC), proton exchange membrane fuel cell(PEMFC).

LO7: Assess the working of different Fuel cells
LO8: Construct and test of Fuel Cell

Textbooks:

1. Electrochemical Engineering by Mantell, C.L. McGraw–Hill
2. Electrochemistry Principles and Applications Edmund Potter, Cleaver–Hume Press Ltd.
3. Handbook of batteries by David linden and Thomas B Reddy, McGraw –Hill

CHEM-1.2.5- ELECTIVE-IV
CHEM-1.2.5 A-ELECTIVE-IV (Corrosion Engineering-II)
Common for M.Tech (Chemical, MPE, IPCE, CACE & Biotechnology)

Objectives:

- To enable the principles of corrosion, common corrosion forms, uniform, galvanic, pitting, inter granular, crevice, dezincification, stress corrosion, corrosion fatigue, hydrogen embrittlement corrosion control methods, and material selection to reduce corrosion cost.
- To enable the ability to understand electrochemical fundamentals
- To enable the ability to understand corrosion preventing methods

Outcome:

- The student would know application of weight loss method
- The student would know application of cathodic protection, anodic ptotection
- At the end of this course, the student would know effective surface preparation of specimen can be done
- After completion of this course, the student would understand the causes and the mechanisms of various types of corrosion, including uniform corrosion, galvanic corrosion, crevice corrosion, pitting corrosion, intergranular corrosion.
- The student would know application of Corrosion Processes and Evans Diagrams and application of electroplating, coatings and importance of inhibitors.

Syllabus:

Corrosion in selective environments: Marine, Acids (Sulfuric acid, Hydrochloric acid, Nitirc acid, Phosphoric acid) Biological and industrial gases (SO_2H_2S).

- Able to understand corrosion and its mechanism in marine atmosphere.
- Able to understand corrosion in acidic media like Sulfuric acid, Hydrochloric,etc.

Corrosion Testing - Purposes, Materials and specimen. Surface preparation, Measuring and weighing , Exposure Techniques - duration, Planned - Interval Tests, Aeration, cleaning specimens after exposure, Temperature, Standard expression for corrosion rates - Galvanic

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Corrosion, Erosion Corrosion, crevice Corrosion, Intergranular corrosion, test for stainless steels, warren test pitting, stress corrosion, Paint tests, Sea Water tests, Presenting and summarizing data - Nomo graph for corrosion rates and interpretation of results.

- Able to understand the importance of surface preparation.
- Able to understand the application of Standard expression for corrosion rates using weight loss method.
- Able to understand the application of different corrosion tests.

Cathodic and anodic protection, surface preparation for coatings and chemical conversions: Degreasing, Descaling , Polishing - Anodized coating : anodizing oxidizing, chromate coating, phosphate coatings - Metallic coatings : Hot dipping, cementation, vapor deposition of metallic coating; Sprayed coatings: flame spraying plasma spraying, Galvanizing - Electroplating : Nickel & chromium coatings, chromizing.- Organic coatings : paints, enamels, lacquers, resin mixtures.

- Able to understand the application of Cathodic and anodic protection.
- Able to understand the uses of Degreasing, Descaling , Polishing.
- Able to understand the importance of Hot dipping, cementation, vapor deposition of metallic coating.

Linings, laminates, reinforced plastic, fibre glass - Corrosion inhibitors: mechanism of inhibition, recirculating of water of water systems.

- Able to understand the importance of Corrosion inhibitors and mechanism of inhibition.

Measurement and testing of preventive coatings ; Thickness and Resistance tests for anodized, Painted, electroplated surfaces using polarization resistance, Linear polarization, curve fit analysis and Electrochemical impedance spectroscopy.

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- Able to understand the Thickness and Resistance tests.
- Able to understand the linear polarization and curve fit analysis.

Reference books :

1. Mars G.Fontana - Corrosion Engineering

2. Burns, R.M., Bradley, W.W., 'protective coatings for Metals.' Chapters 2 to 18.

Reference Books :

Corrrosion Volumes 1 & 2 by L.L. Shrier, Newnes - Butter-worths, London.

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CHEM- 1.2.5 B - Elective-IV (Energy Engineering-II)
Common for M.Tech (Chemical, MPE, IPCE, CACE & Biotechnology)

Course objectives:

1. The student is provided with the fundamentals of renewable energy processes.
2. Basic information to comprehend the various non-conventional energy systems would be illustrated to the student.
3. Various ways of obtaining energy from ocean can be demonstrated to the student.
4. The methods of energy conservation and the opportunities for conservation would be emphasized.
5. Economics involved in the energy production processes would be enumerated to the student.

Course Outcomes:

1. Methods to be adopted to utilize biomass as an important energy source
2. Application of thermodynamics to obtain energy from various sources
3. Possible mechanism to draw energy from wind and other natural resources
4. Knowledge about energy conservation and storage
5. Emerging technologies to produce energy such as thermionics, thermoelectricity etc.

Syllabus:

Fundamentals of energy science and technology: Introduction – Energy, economy and social development – Oil crisis of 1973 – classification of energy sources – consumption trend of primary energy resources – importance of non-conventional energy sources – energy chain – common forms of energy – advantages and disadvantages of conventional energy sources – salient features of non-conventional energy sources – energy densities of various fuels – environmental aspects of energy – The United Nations Framework Convention on Climate Change – Energy-environment-economy – World energy status – energy scenario in India. **Energy conservation and efficiency:** Introduction – important terms and definitions – important aspects of energy conservation – global efforts, achievements and future planning – energy conservation/efficiency scenario in India – energy audit – energy conservation opportunities –

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cogeneration – combined cycle plants. **Energy storage:** Introduction – necessity of energy storage – specifications of energy storage devices – energy storage methods.

Learning outcomes:

1. The student can identify the ways and means of conservation of energy once the student completes learning this unit.
2. The student can appraise the necessity of energy storage and recommend the methods for energy storage at the end of the unit.

Wind energy: Introduction – origin of winds – nature of winds – wind turbine siting – major applications of wind power – basics of fluid mechanics – wind turbine aerodynamics – wind turbine types and their construction – wind energy conversion systems – wind-diesel hybrid system – effects of wind speed and grid condition – wind energy storage – environmental aspects – wind energy program in India.

Learning outcomes:

1. By studying this unit, the students will be able to predict where the wind power plants can be located.
2. At the end of this unit, the students can recommend appropriate technology for obtaining geothermal energy in a given situation.

Biomass: Introduction – Photosynthesis process – usable forms of biomass, their composition and fuel properties – biomass resources – biomass conversion technologies – urban waste to energy conversion – biomass gasification – biomass liquefaction – biomass to ethanol production – biogas production from waste biomass – energy farming. **Geothermal energy:** Introduction – applications – origin and distribution of geothermal energy – types of geothermal resources – analysis of geothermal resources – exploration and development of geothermal resources – environmental considerations – geothermal energy in India.

Learning outcomes:

1. After completing this unit, the students will be able to choose appropriate biogas plant for a given location and able to provide dimensions of the same. .
2. At the end of this unit, the students will be able to recommend a process for utilizing the biomass for a given application.

Ocean Energy: Introduction: Tidal energy – wave energy – ocean thermal energy. **Small hydro resources:** Introduction – advantages and disadvantages of small hydro schemes – layout of a micro-hydroscheme - water turbines – turbine classification, characteristics and selection – generators – present status.

Learning outcomes:

1. At the end of this unit, the students can recommend appropriate technology for obtaining energy from ocean in a given situation.
2. Suitable scheme for generating electricity from small hydroresources can be suggested by the student after the completion of this unit.

Emerging technologies: Introduction – fuel cell – hydrogen as energy carrier. **Miscellaneous non-conventional energy technologies:** Introduction – magneto hydrodynamic power conversion – thermoelectric power generation – thermionic power conversion. **Financial and economic evaluation:** Introduction – basic terms and definitions – calculations for the case of single payment – calculation for uniform series of payments – calculations for uniform gradient series of payments – calculations for geometric gradient series of payments – effect of inflation on cash flows – comparative economic evaluation of alternatives – effect of depreciation and tax on cash flow.

Learning outcomes:

1. New technologies for obtaining energy from various renewable sources can be evaluated by the student.
2. Economic factor in the energy production by various technologies can be compared by the student at the end of this unit.

Text book:

Non-Conventional Energy Resources by B.H. Khan, 3/e, McGraw Hill (2017).

Reference book:

Fundamentals of Renewable Energy Processes by Aldo V. Da Rosa. Elsevier (2005).

CHEM- 1.2.5 C - Elective-IV (Reaction Engineering-II)
Common for M.Tech (Chemical, MPE, IPCE, CACE & Biotechnology)

Syllabus:

UNIT - I

Laboratory Reactors - Interpretation of Experimental Data - Interpretation of Laboratory Kinetics Data - Homogeneous and Heterogeneous Laboratory Reactors. Calculation of Global Rate - The structure of Reactor Design.

(Scope: Chapter 12 of J.M Smith 3rd Edition)

UNIT - II

Design of Heterogeneous Catalytic Reactors Isothermal and Adiabatic Fixed Bed Reactors Non-isothermal, Non-adiabatic Fixed Bed Reactors.

(Scope: Chapters 13.1 - 13.9 of J.M Smith 3rd Edition)

UNIT - III

Design of fluidized bed Reactors - Two -Phase Fluidized Bed model - Operating characteristics - Slurry Reactors - Trickle - Bed Reactors - Optimization.

(Scope: Chapter 13.10 - 13.13 of J.M Smith 3rd Edition.)

UNIT - IV

Fluid - Solid Noncatalytic Reactions - Design concepts - Single Particle Behavior - Reactor Models.

(Scope: Chapter 14 of J.M Smith 3rd Edition)

UNIT - V

Short notes from the portions of all the above four units. Four bits are to be answered out of 7 bits (Not more than 2 bits to be given from any one Unit).

Text Book: Chemical Engineering Kinetics by J.M Smith, McGraw - Hill Book Company , 1980, 3rd Edition.

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CHEM 1.2.6: AUDIT COURSE -2
CHEM 1.2.6 A : DISASTER MANAGEMENT (Audit Course -2)
Common for M.Tech (Chemical, MPE, CACE, IPCE, Biotechnology)

Introduction to Disaster: Definition, Factors And Significance; Difference Between Hazard And Disaster; Natural And Manmade Disasters: Difference, Nature, Types and Magnitude.

Repercussions Of Disasters And Hazards: Economic Damage, Loss of Human And Animal Life, Destruction Of Ecosystem. Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts And Famines, Landslides And Avalanches, Man-made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks And Spills, Outbreaks Of Disease And Epidemics, War And Conflicts.

Disaster Prone Areas in India Study Of Seismic Zones; Areas Prone To Floods And Droughts, Landslides And Avalanches; Areas Prone To Cyclonic And Coastal Hazards With Special Reference To Tsunami; Post-Disaster Diseases And Epidemics

Disaster Preparedness And Management Preparedness: Monitoring Of Phenomena Triggering A Disaster Or Hazard; Evaluation Of Risk: Application Of Remote Sensing, Data From Meteorological and Other Agencies, Media Reports: Governmental And Community Preparedness.

Risk Assessment Disaster Risk: Concept and Elements, Disaster Risk Reduction, Global and National Disaster Risk Situation. Techniques of Risk Assessment, Global Co-Operation In Risk Assessment and Warning, People's Participation In Risk Assessment. Strategies for Survival

Disaster Mitigation Meaning, Concept and Strategies Of Disaster Mitigation, Emerging Trends In Mitigation. Structural Mitigation And Non-Structural Mitigation, Programs Of Disaster Mitigation In India.

REFERENCES:

1. R. Nishith, Singh AK, "Disaster Management in India: Perspectives, issues and strategies "'New Royal book Company.

2. Sahni, PardeepEt.Al. (Eds.)," Disaster Mitigation Experiences and Reflections", Prentice Hall Of India, New Delhi.

3. Goel S. L., Disaster Administration And Management Text And Case Studies",Deep & Deep Publication Pvt. Ltd., New Delhi.

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CHEM 1.2.6 B: ENTREPRENEURSHIP (Audit Course -2)

Common for M.Tech (Chemical, MPE, CACE, IPCE, Biotechnology)

Unit -I : Basic Concepts of Management:Management :- Definition, Nature and Importance ; Functions of the Management; Levels of Management; F.W Taylor's Scientific Management; Henry Fayol's Principles of Management.

Unit-II : Forms of Business Organizations: Introduction, Types of Business organizations: Private Sector- Individual Ownership , Partnership, Joint stock companies and Co-Operative organizations; Public sector- Departmental Organizations, Public Corporations and Government Companies; The Joint sector Management.

Unit-III Production and operations Management: Plant location- Factors to be considered in the selection of Plant location; Break - even analysis- Significance and managerial applications; Importance of Production Planning and Control and its Functions; Human Resource Management and Functions of Human Resource Manager (in brief); Functions of Marketing; Methods of Raising Finance.

Unit-IV : Entrepreneurship: Definition, Characteristics and Skills, Types of Entrepreneurs, Entrepreneur vs. Professional Managers, Growth of Entrepreneurs, Nature and Importance of Entrepreneurs, Women Entrepreneurs, Problems of Entrepreneurship.

Unit-V : Entrepreneurial Development and Project Management: Institutions in aid of Entrepreneurship Development, Idea generation: Sources and Techniques; Stages in Project formulation; Steps for starting a small enterprise - Incentives for Small Scale Industries by Government.

Text Books:

1. Sharma, S.C, and Banga, T.R., Industrial Organization & Engineering Economics, Khanna Publishers, Delhi, 2000.

2. Vasant Desai, The Dynamics of Entrepreneurial Development and Management (Planning for future Sustainable growth), HImalayan Publishing House, 2018.

Reference Books:

1. Aryasri, A.R., Management Science, McGraw HIll Education (India Private Limited, New Delhi 2014.

2. Sheela, P. and Jagadeswara Rao, K., Entrepreneurship, Shree Publishing House, Guntur,

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III SEMESTER

CHEM-2.1.1: Elective –V

CHEM-2.1.1 A : Elective-V (Process Modeling and Simulation)
Common for M.Tech (Chemical, MPE, CACE & IPCE)

Objective:

Deals with writing various process models based on basic physical process. It also deals with solving the various models by means of numerical methods by computer simulation. By studying this course, one can simulate various chemical processes by computer simulation.

Outcome:

Understand the writing of a model of a process based on basic physical processes like mass, momentum and energy balances.

1. Able to develop a model equation for Tanks, Isothermal and Non-Isothermal Systems
2. Able to understand the models for binary distillation column, batch reactors, etc.
3. Able to solve the model equations by numerical methods.

Syllabus:

Principles of formulation - Continuity equations – Energy equation – Equation of motion – Equations of state – Transport equations – Chemical Kinetics – Algebraic and Integral / differential equations, Explicit and Implicit equations –Numerical Integration,Feed forward and feed backward control.

Basic modeling for tank system, mixing vessel – Simultaneous mass and energy balances – Models for boiling, batch distillation, and partial condenser.

Models for Reactor – Model for heterogeneous catalysis – Models for pumping system – Model for heat exchanger.

Operational blocks in simulation- Simulation Programming – Simulation examples of three CSTR's in series, gravity flow tank, binary distillation column, non–isothermal CSTR.

Implicit function convergence ,Internal–halving convergence, Newton–Raphson method, False position convergence, Explicit convergence methods, Numerical Integration, Euler Integration, Runge - Kutta (fourth order) method.

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Textbooks:

1. Process Modeling, Simulation and Control for Chemical Engineers by Luyben, W.L., McGraw Hill Books Co.
2. Mathematical Modeling in Chemical Engineering by Roger, G.E. Franks – John Wiley Sons Inc.

Reference Book:

Mathematical Methods in Chemical Engineering by V.G. Jenson and G.V. Jefferys, Academic Press – 2nd Edition.

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CHEM-2.1.1 B : Elective-V (COMPUTATIONAL METHODS)

Objective:

The main purpose of teaching ”COMPUTATIONAL METHODS” for the first year M.TECH students is to introduce the basics of computational techniques subject for CACE specialization students to gain fair knowledge of overall computational techniques. To learn various computational methods which are available to solve the chemical engineering problems which are related to computer aided chemical engineering applications.

Out come:

Student gains fair knowledge which every CACE specialization student should know to solve the problems. Student will learn the importance of solving the problems. Student is able to gain the complete knowledge on the subject. This knowledge is very helpful for the student to solve the different types of problems in Chemical Industry with different computational methods.

Syllabus:

1. Linear and Non-linear Algebric Systems:

Elimination methods for solving linear systems, matrix inversions, factorization, norm and rank; Solutions of nonlinear algebric equations, iterative methods, methods of Newton, Secant, Bracketing and Bisection, Newton's methods for multiple non-linear equations, Jacobian, Quasi-Newton methods.

2. Matrix Eigen Value Analysis:

Orthogonal matrices, eigen values and vectors of real matrix, eigen values and properties of linear systems, estimating eigen values, eigen vector matrix decomposition and basis sets, numerical calculation eigen values and vectors, extremal eigen values, QR method, Single Values Decomposition, eigen problems in quantum mechanics, computing the roots of polynomial.

3. Initial Value Problems:

Initial Value Problems of ordinary differential equations, polynomial interpolation, Newton Cotes integration, Gaussian quadrature, multi dimensional integrals, dynamic stability, accuracy and stability of single step methods, stiff stability of BDF methods, simplistic methods for classical mechanics, differential-algebraic equation systems, parametric continuation.

4. Boundary Value Problems (BVPs)

BVPs from conservation principles, real space versus function space methods, finite difference methods for 2-D BVP, extension of finite difference method, chemical reaction and diffusion in spherical

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catalysts pillet, conversion/diffusion equation, modeling a tubular reactor with dispersion, numerical issues for discretized PDEs with more than tow spatial dimensions, finite differences in complex geometries, finite volume method, finite element method (FVM).

Text book:

K.J.Beers, Numerical Methods for Chemical Engineering, Cambridge University Press, 2006.

Reference books:

1. B.A. Finlayson, Introduction to Chemical Engineering Computing, John Wiley, 2006
2. A.Constantinides and N.Mostoufi, Numerical Methods for Chemical Engineers with MATLAB Applications, Prentice Hall, 1999.
3. A.Varma and M.Morbidelli, Mathematical Methods in Chemical Engineering, Oxford University Press 1997
4. M.B.Cutlip and M.Shachasm, Problem Solving in Chemical Engineering with Numerical Methods, Prentice Hall, 1999
5. OT.Haanna and IO.C.Sandall, Computational Methods in Chemical Engineering, Prentice Hall, 1995
6. J.H.Mathews and K.D.Fink, Numerical Methods using MATLAB, 4th ed.,Prentice-Hall India Private Limited, 2005

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CHEM-2.1.1 C : Elective-V (Advanced Engineering Mathematics & Statistics)
Common for M.Tech (Chemical & CACE)

Objective:

The main objective is to make the students get familiar with the Advanced Numerical Methods and Statistical techniques by learning them. The student should be able to learn how to get the Numerical solutions of Boundary value problems as these arise in several engineering studies, such as in Hydrodynamics, Quantum mechanics, applied elasticity, Heat and Mass transfer etc. The student should be able to study about Probability and Statistics; which provides a mathematical frame work for different assertions and is essential in every decision-making process.

Outcome:

The Students come out with the good knowledge of Advanced Numerical Methods and Statistical Techniques and they will be able to implement these techniques whenever required in their further studies.

SYLLABUS:

1. **Finite Difference Methods of Solving Boundary value problems Associated with partial Differential Equations:** Introduction, Finite difference scheme for Laplace's equation, Finite difference methods for the parabolic type of partial differential equations, Forward difference method, Crank-Nicholson implicit method, Stability analysis, backward difference equation for parabolic equations, finite difference explicit scheme for the wave equation. An implicit scheme for the linear wave equation, method of characteristics for solving hyperbolic partial differential equations.

2. **Boundary value problems in ordinary differential equations:** Reduction to an intial value problems, Finite difference method, The shooting method, Multiple integration.

3. **Statistics and probability:** Concept of random variable – distribution and density functions conditional distribution and density functions, Functions of one and two random variables, Many random variables, Concept of Stochastic Processes.

Textbooks:

1. Computer Programming and Numerical Analysis by N.Datta Published by Universities Press(India) Private Limited, 3-5-819, Hyderabad – 500029 for Section I & II.
2. Probability by Seymour Lipschutz: Schaum's outline series for Section III.
3. Introductory Methods of Numerical Analysis by S.S.Sastry.

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CHEM-2.1.2: Elective –VI (Open Elective)
CHEM-2.1.2 A : Elective-VI (Nanotechnology)
Common for M.Tech (Chemical, MPE, CACE, IPCE, Biotechnology)

Objectives:

Nanotechnology may be treated as **Green technology**. It is one of the most advanced technologies now-a-days. It leads to have revolutionary changes in the fields of medical, Bio-medical, and fabrication of materials. Technologists are able to prepare ageless materials with the help of nano-techniques. Main objectives of the subject nanotechnology are :

1. To define green technology properly
2. To expose the students with new techniques of the nanotechnology.
3. To make them to learn the importance of quantum technology
4. To learn the procedure ageless materials to avoid wear-tear.
5. To learn the importance of nano –robots, machines
6. To know about the latest microscopes such as SEM, TEM
7. To know the importance of nanotechnology in the dawn of optical instruments

Outcome:

1. Application of nanotechnology in the development of energy
2. Application of nanotechnology in the development of solar panels, Fuel cells
3. Knew the importance of atoms manipulation
4. Knew that the applications of nanoparticles in the development of DVD, LEDs etc.
5. Biomedical applications in terms of preparing artificial, drug delivery, encapsulation, addition to that pharmaceuticals.

Syllabus:

1. Introduction to nanotechnology, molecular and atomic size, surface and dimensional spaces. Molecular nanotechnology: atoms by inference, electron microscopes, nanomanipulator, nanotweezers, atom manipulation, nanodots, nanolithography.

Learning Outcomes:

- Define the term nanotechnology to understand in a better way the subject basics
- Demonstrate the different types of Electron Microscopes and their uses.

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2. Nanopowders and nanomaterials: preparation, plasma arcing, chemical vapor deposition, sol-gels, electrodeposition, Ball milling, applications. Carbon nanotubes: types, formation, assemblies, purification, properties and uses.

Learning Outcomes:

- Summarize the nanomaterials used for the preparation of nanopowders
- Apply and selection of the different methods to prepare nanopowders
- Classify the carbon nanotubes and purification process.

3. Molecular mimics: Catenanes and rotaxanes, various molecular switches, synthesis of rotaxanes and catenanes, molecular computers, chemical rotors, prodders, flippers, atom shuttles, actuators, contacts.

Learning Outcomes:

- Categorize the molecular switches and synthesis of rotaxane and catenanes
- Examine the function of molecular computers

4. Nanobiometrics: Lipids as nano-bricks and mortar, self – assembled monolayers, proteins, 3-D structures arising from amines acids, nanoscale motors, Biological Computing, ion channels as sensors, Information in DNA structure, using DNA to build nano-cubes, hinges, smart glue, wire template.

Learning Outcomes:

- Evaluate the importance of nanobiometrics as self-assembled monolayers and nanoscale motors.
- Explain the process of biological computing and using DNA as hinges, smart glue, wire template

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5. Optics, photomics and solar energy: Properties of light and nanotechnology, Interaction of light and nanotechnology, Nanoholes and photons, Imaging, New low cost energy efficient windows and solar absorbers based on nanoparticles, Photonic crystals, surface wave guides and control of light paths.

Learning Outcomes:

- Discuss about the optics, photomics and solar energy with reference to light properties.
- Chose a technique using nanoparticles to manufacture solar absorber, photonic crystals and change the light path.

6. Nanoelectrons: birth of electrons, semiconductors, transistor, integrated circuits, the tools of micro and nanofabrication, quantum electronic devices, quantum information and quantum computers, experimental implementations of quantum computers.

Learning Outcomes:

- Appraise different phased in the development of nanoelectornics tools.
- Construction of quantum computers and its experimental implementations.

7. Future applications: microelectomechanical systems, nano-robots , ageless materials, invisible mending of atomic dislocations inside damaged materials, nanomechanics and nanoelasticity, nanoparticle coatings, nanoelectronic and magnetic devices and new computing systems, optoelectronic devices, environmental applications.

Learning Outcomes:

- Assess the future application of nanotechnology in various fields
- Create new tools with nanotechnology to prepare new devices

Text-book: M.Wilson, K.Kannangara, G. Smith, M. Simmons and B. Ragues, **Nanotechnology**, Overseas press (India) Private Ltd; New Delhi, 2005.

Reference books:

1. G. Ali Mansoori*, **Principles of Nanotechnology**, World Scientific Publishing Company, 2005.
2. G. Timp, Nanotechnology, Springer-Verlag, Network, 1999.
3. P. Poole and F.J. Owens, Introduction to Nanotechnology, John Wiley, 2003.
4. D.Ratner and M.Ratner, Nanotechnology: A Gentle Introduction, Pearson Education,2003.
5. B. Bhusan, Handbook of Nanotechnology, Springer, 2004

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CHEM-2.1.2 B: Elective-VI (POLLUTION CONTROL)
Common for M.Tech (Chemical, MPE, CACE, IPCE, Biotechnology)

Objectives:

- Focus on classification of air pollutants, water pollutants and solid waste –causes, effects and control methods, need of environmental Legislation.

Outcome:

- Enables the students to adopt the preventive measures for the control of air pollutants, waste water treatment methods, and solid waste management methods in domestic, municipal waste.
- Enables the students to understand the control measures of pollutants emitted from different industries like Paper and pulp, fertilizer, sugar and alcohol, petrochemical and petroleum refinery, pharmaceutical and metal finishing industries.

Syllabus:

Kinds of ecology, environment and ecofactors, types of ecosystems, sulphur cycles, phosphorous cycle, Nitrogen cycle and hydrological cycle

Sources for water, Air and solid pollution, Analysis and effects of the pollutants in air, in water, Solids(particulate matter, SOx, NOx, Cox, CHx).

Limits of pollutants, Environmental Legislation.

Control aspects of various pollutants Air (Particulate matter, SOx, NOx, COx, CHx, Noise) water (primary, secondary and territory treatment techniques) Solids (recycling, incineration,bio-conversion).

Case studies of Industries: Paper and pulp, petrochemical, Fertilizer, Pharmaceuticals, tannery, sugar and alcohol industries, metal finishing industries.

Learning Outcomes:

- Describe different ecosystems
- Explains the bio-geochemical cycles
- classify the main types of pollution and their effects
- Describe the sources of pollution and their characteristics
- Describe the effects of air and water pollution on the environment and on human health
- Explain the importance of Environmental Legislation for pollution prevention and control
- Evaluate the preventive measures for the control of air pollutants – SPM

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- Select the most appropriate technique to control SOx, NOx, COx, CHx
- Describe the primary, secondary and territory treatment techniques waste water treatment methods
- Propose control measures of pollutants emitted from different industries like paper and pulp
- Plan to select most appropriate technique to control pollutants from petrochemical and refineries
- Explain the control aspects of pollutants from Fertilizer, Pharmaceuticals
- Elucidate the control aspects of pollutants from tannery, sugar and alcohol industries, metal finishing industries

Text books:-

1. S.P.Mahajan., Pollution control in process Industries, Tata McGraw hill publishing company.
2. Arcadio P. Sincero and Georgia Sincero., Environmental Engineering
3. Environmental Pollution Control., by C.S.Rao, wiely eastern ltd.

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CHEM-2.1.2 C: Elective-VI (Corrosion Engineering)
Common for M.Tech (Chemical, MPE, CACE, IPCE, Biotechnology)

Course Objectives:

- Basic aspects of electrochemistry relevant to corrosion phenomena,
- Importance and forms of corrosion.
- Knowledge on corrosion rate expressions and measurement techniques.
- Basic knowledge on remedial measures for corrosion.

Course Outcomes:

At the end of the course, the student will be able to

- Identify various forms of corrosion.
- Determine corrosion rates for metals from their polarization curves
- Analyze corrosion rate characteristics from electrochemical impedance spectroscopy
- Select suitable corrosion resistant coatings, oxide layers for various applications

Syllabus

Introduction and scope: Corrosion definition, wet and dry corrosion, mechanism, electro-chemical principles and aspects of corrosion, Faradays laws, resistance, specific resistance, conductance, specific conductance, transport numbers, ionic mobility, corrosion rate expressions, calculation of corrosion rates, thermodynamic aspects of corrosion, equilibrium potential, Nernst equation for electrode potential, EMF series, over voltage, application of Nernst equation to corrosion reactions,

Polarisation and corrosion potentials: References electrodes for corrosion measurements, types of polarisation, concentration, activation and resistance polarizations, Tafel constant, Evans diagrams, anodic control, cathodic control, mixed control, Pourbaix-diagram for Fe-H_2O system,

Various forms of corrosion: Uniform attack, galvanic corrosion, crevice corrosion, pitting corrosion, intergranular corrosion, selective leaching (dezincification), cavitation damage, fretting corrosion, erosion corrosion, and stress corrosion and remedial measures,

Prevention techniques: Modification of the material by alloying, appropriate heat treatment, chemical and mechanical methods of surface treatment, metallic, non-metallic linings, inhibitors, passivity, Cathodic protection and anodic protection.

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TEXT BOOKS:

1. 'Corrosion Engineering' by Mars G. Fontana, Tata McGraw Hill Publishing Company, New Delhi
2. 'Corosion and Corrosion Control' by H.H.Uhllg, John Wiley & Sons Inc., America

REFERENCE BOOKS:

1. 'Electrochemistry' by Samuel Glasstone, Litton Educational Publishing Company
2. 'Electrochemistry, Principles & Applications' by Edmond C.Potter, Cleaver Hume Press Limited

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