**M.TECH.**

**(INDUSTRIAL POLLUTION CONTROL ENGINEERING)**

**(Effective from the admitted batch of 2019-20)**

**Scheme and Syllabi**

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**DEPARTMENT OF CHEMICAL ENGINEERING**

**AU COLLEGE OF ENGINEERING (A)**

**ANDHRA UNIVERSITY**

**VISAKHAPATNAM**

**DEPT OF CHEMICAL ENGG:: A.U.COLLEGE OF ENGINEERING(A)**

 **SCHEME OF INSTRUCTION & EXAMINATION**

**1/2 M.TECH(IPCE) FIRST SEMESTER**

**(WITH EFFECT FROM 2019-20 ADMITTED BATCH ONWARDS)**

**UNDER CHOICE BASED CREDIT SYSTEM**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Code No.** | **Course** | **Credits** | **Theory** | **Tutorial** | **Lab** | **Total** | **Sessional marks** | **Exam marks** | **Total marks** |
| IPCE-1.1.1 | Process Modeling & Simulation | 4 | 3 | 1 | -- | 4 | 30 | 70 | 100 |
| IPCE-1.1.2 | Process Dynamics and Control  | 4 | 3 | 1 | -- | 4 | 30 | 70 | 100 |
| IPCE-1.1.3 | Chemical Reaction Engineering | 4 | 3 | 1 | -- | 4 | 30 | 70 | 100 |
| IPCE-1.1.4 | Transport Phenomena  | 4 | 3 | 1 | -- | 4 | 30 | 70 | 100 |
| IPCE-1.1.5 | Elective-I | 4 | 4 | -- | -- | 4 | 30 | 70 | 100 |
| IPCE-1.1.6 | Elective-II | 4 | 4 | -- | -- | 4 | 30 | 70 | 100 |
| IPCE-1.1.7 | IPCE lab | 2 | -- | -- | 3 | 3 | 50 | 50\* | 100 |
| IPCE-1.1.8 | Seminar | 2 | -- | -- | 3 | 3 | 100 | -- | 100 |
|  | TOTAL | 28 | 20 | 4 | 6 | 30 | 330 | 470 | 800 |

\*Only internal evaluation.

Elective-I: 1.Management and control of industrial wastewater and solids

 2. Petroleum Refinery Engineering-I

 3. Electrochemical Engineering-I

Elective-II: 1. Corrosion Engineering-I

 2. Energy Engineering-I

 3. Reaction Engineering-I

**DEPT OF CHEMICAL ENGG :: A.U.COLLEGE OF ENGINEERING(A)**

 **SCHEME OF INSTRUCTION & EXAMINATION**

**1/2 M.TECH (IPCE) SECOND SEMESTER**

**(WITH EFFECT FROM 2019-20 ADMITTED BATCH ONWARDS)**

**UNDER CHOICE BASED CREDIT SYSTEM**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Code No.** | **Course** | **Credits** | **Theory** | **Tutorial** | **Lab** | **Total** | **Sessional marks** | **Exam marks** | **Total marks** |
| IPCE-1.2.1 | Computer Aided Design  | 4 | 3 | 1 | -- | 4 | 30 | 70 | 100 |
| IPCE-1.2.2 |  Air Pollution Control In Industry | 4 | 3 | 1 | -- | 4 | 30 | 70 | 100 |
| IPCE-1.2.3 |  Analytical Techniques | 4 | 3 | 1 | -- | 4 | 30 | 70 | 100 |
| IPCE-1.2.4 |  Environmental Biotechnology  | 4 | 3 | 1 | -- | 4 | 30 | 70 | 100 |
| IPCE-1.2.5 | Elective-III | 4 | 4 | -- | -- | 4 | 30 | 70 | 100 |
| IPCE-1.2.6 | Elective-IV | 4 | 4 | -- | -- | 4 | 30 | 70 | 100 |
| IPCE-1.2.7 | IPCE lab | 2 | -- | -- | 3 | 3 | 50 | 50 | 100 |
| IPCE-1.2.8 | Seminar | 2 | -- | -- | 3 | 3 | 100 | -- | 100 |
|  | TOTAL | 28 | 20 | 4 | 6 | 30 | 330 | 470 | 800 |

Elective-III: 1. Industrial Hazards, Safety Measures & Environmental Impact Assessment

 2. Petroleum Refinery Engineering-II

 3. Electrochemical Engineering-II

Elective-IV: 1. Corrosion Engineering-II

 2. Energy Engineering-II

 3. Reaction Engineering-II

**DEPT OF CHEMICAL ENGG :: A.U.COLLEGE OF ENGINEERING(A)**

 **SCHEME OF INSTRUCTION & EXAMINATION**

**2/2 M.TECH (IPCE) FIRST & SECOND SEMESTER**

**(WITH EFFECT FROM 2019-20 ADMITTED BATCH ONWARDS)**

**UNDER CHOICE BASED CREDIT SYSTEM**

**PROJECT WORK:**

CHEM-2.1.1 - FIRST SEMESTER: CREDITS:10, MARKS:100

CHEM-2.2.1- SECOND SEMESTER: CREDITS:14, MARKS:100

* Project guide will be allotted at the beginning of first semester and the student has to give presentation on his/her project work at the end of first semester and grading will be awarded as A,B,C or F.
* At the end of second semester final viva-voce examination will be conducted and grading will be

 awarded as A,B,C or F.

SYLLABUS

M.TECH. I SEMESTER

IPCE-1.1.1: PROCESS MODELING AND SIMULATION

(Common for MPE, CACE & CHEMICAL )

Objective:

 Process modeling and Simulation is a important subject of study for Post Graduate Chemical Engineers . It deals with writing various process models based on basic physical process. It also deals with solving the various models by means of various numerical methods by computer simulation. By studying this course ,one can simulate various chemical process by computer simulation .

**Outcome:**

1. Understand the writing of a model of a process based on basic physical processes like mass ,momentum and energy balances
2. Develop a model equation for Tanks, Isothermal and Non-Isothermal Systems
3. Understand the models for Binary Distillation Column, Batch Reactors etc
4. Solve the model equations by Numerical methods like Euler and Runge –Kutta etc

**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.

**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.

**IPCE-1.1.2: PROCESS DYNAMICS & CONTROL**

**(Common for MPE, CACE & CHEMICAL )**

**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:**

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

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

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

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

Control of heat exchangers, distillation columns and Chemical 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.

**PCE-1.1.3 : CHEMICAL REACTION ENGINEERING**

**(Common for MPE, CACE & CHEMICAL)**

**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.

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.

**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.

**IPCE-1.1.4: TRANSPORT PHENOMENA**

**(Common for MPE, CACE & CHEMICAL )**

***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. The Equations of change for isothermal systems.
	2. Velocity distributions with more than one independent variable.
	3. Velocity distributions in turbulent flow.
	4. Inter phase transport in isothermal systems.

 Unit 2: Energy Transport

* 1. The Equations of change for non – isothermal systems.
	2. Temperature distributions with more than one independent variable.
	3. Temperature distributions in turbulent flow.
	4. Interphase transport in nonisothermal systems.

 Unit 3: Mass Transport

* 1. The Equations of Change for multicomponent systems.
	2. Concentration distribution with more than one independent variable.
	3. Concentration distribution in turbulent flow.

**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.

**IPCE-1.1.5: Elective – I**

**IPCE- 1.1.5 A - Elective-I (Management and control of industrial wastewater and solids)**

**Objective:**

The course is designed as tailor-made approach to know the fundamental concepts and various technologies of industrial wastes and solid waste management helpful the students in brightening chances for getting wide range of employability both in industrial and community organizations

**Outcome:**

1. On completion of the subject course, the students will have the scope to learn various theoretical and technical aspects of industries waste water treatment and solid waste management methods which are very significant in industrial sector
2. The course will add the design approach of Effluent Treatment Plants and solid waste recovery and recycling techniques and the students can brighten their chances of job opportunity in corporate companies engaged in design of pollution control equipments
3. Sludge treatment aspects of the course will be helpful to students for further enhancing their skills when they take up practical assignments
4. The course will lay down a basic platform to persue further research in the specific fields the interest of students
5. Enhance the knowledge of latest practices being adopted in the field of wastewater treatment and solid waste management and helpful the students who take up their career in academic line

**Syllabus:**

**I. Source of Industrial wastewater:** Types, permissible limits, **sources and pollutants** - BOD, COD, TOC, sampling and analysis of industrial wastewater, **impacts on** - soil, irrigation, animal husbandry, plants, ecosystems and public health aspects

**II. Primary and secondary treatment methods:** screening, sedimentation, flotation and neutralization, bacterial and bacterial growth curve, aerobic processes, suspended processes, activated sludge processes, extended growth processes, contact stabilization, aerated lagoons and stabilization ponds, attached growth processes, trickling filters, rotary disk contractors, fluidized bed contractors, anaerobic processes

**III. Tertiary treatment techniques:** carbon adsorption, ion-exchange, reverse osmosis, ultra filtration, ozonation, sonozone processes, chlorination

**IV. Sludge treatment and disposal:** overview, mass volume relationships, secondary clarification and gravity thickness, aerobic & anaerobic digestion, cake filtration, composting, sludge disposal

**V. Solid waste Management:** **Terminology** – liquid waste, solid waste, refuse, garbage & food waste, rubbish, white goods, rubble. **Solid waste characteristics** – generation rates, components, moisture content, density, proximate and ultimate analysis and energy content, **solid waste collection & transportation** – haul – container system, stationary container system, layout of collection routes, transfer stations, **solid waste processing and recovery** – recovery of materials for recycling, manufacturing of solid waste products, energy recovery, **disposal of solid wastes** – land filling methods, aspects of landfill implementation, sanitary landfill equipment

Textbooks:

1. “Industrial Pollution Control” by C.S.Rao
2. “Environmental Engineering – A design approach” by Arcadio P. Sincero and Gregoria A. Sincero

**IPCE- 1.1.5 B - Elective-I (Petroleum Refinery Engineering-I)**

**Objective:**

To introduce the basics of refinery engineering subject for petroleum specialization students to gain knowledge of the overall refinery operations, refinery products and its test methods. To learn various primary and secondary cracking process available to produce normal and value added products. Further, to learn the treatment process available to remove the impurities in the crude and finished products and its test methods for quality check.

**Outcome:**

Student gains very basic knowledge which every petroleum specialization student should know to work in the refinery field. Student will learn the importance of quality check and different methods available for quality check. Student learns about various treatment processes available to increase the quality of the product. Student is able to gain complete knowledge on the process available including operating conditions, reaction kinetics, catalyst, products, etc. This knowledge is very helpful for the student to have primary and basic knowledge of the process in advance before delivering the duty as process engineer.

**Syllabus:**

***Origin and formation of petroleum***: Reserves and deposits of the world - Indialn petroleum industry - Composition of crudes.

***Refinery products specifications and test methods***: Evaluation of crudes. Crudes Pretreatment dehydration and desalting. Physical properties of petroleum oils and products.

Introduction to processing- Refinery distillation - processes - catalytic cracking, Reforming Hydro cracking , and hydro treating, hydrosulfurization.

***Chemical treatments & Extraction Processes*** *:* Alkylation, polymerization Lube oil processing.

***De-waxing*** *:*

Asphalt and air blown asphalt.

Treatment of products, additines, blending of gasoline, treatment of gasoline, Kerosene etc.,

***Heat transfer equipment in Refinery*** - Heat exchangers and pipe still heaters.

Design of atmospheric distillation tower and Vacuum distillation tower, catalytic cracking units.

**Text Books :**

1. Petroleum Refinery Engineering - Nelson.
2. Refinery distillation - Watkins.

# **IPCE- 1.1.5 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 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.

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.

 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.

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.

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.

**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’.

**IPCE-1.1.6: Elective –II**

**IPCE-1.1.6 A - Elective-II (Corrosion Engineering-I)**

**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:**

1. Acquires knowledge on basic principles of electrochemistry, importance of corrosion, corrosion tendency and electrode potentials.
2. Able to identify the nature of corrosion and form in which it attacks(Uniform attack, Galvanic Corrosion, Crevice Corrosion, Pitting, Intergranular Corrosion, Selective Leaching, Erosion Corrosion and Stress Corrosion. Hydrogen damage .
3. By acquiring knowledge on polarization and its influence on corrosion rates will be able to measure corrosion rates and analyze.
4. Acquires knowledge on mechanism 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.

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.

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.

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.

**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.

**IPCE- 1.1.6 B - Elective-II ( Energy Engineering-I)**

**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**

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).

**IPCE- 1.1.6 C - Elective-II (Reaction Engineering-I)**

**Syllabus:**

**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 (K1) - Mass transfer coefficients: Liquid to particle (Kc) - The effect of mass - transfer on observed rates Trickle - Bed reactors - mass transfer coefficients: Gas to liquid (K1 ag) - Liquid to particle (kc ac) - 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.

**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.

**II SEMESTER**

**IPCE–1.2.1 - COMPUTER AIDED DESIGN**

(Common for Chemical and 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:**

**Introduction**, preliminary data base creation, preliminary process synthesis, development of base case design, principles of steady state simulation, developing information flow diagram, information flow diagram to numerical form, planning calculations, finding recycles, planning calculations of a recycle set.

**Mass transfer operations**: Introduction, distillation- simple binary distillation, multicomponent flash calculations, multicomponent 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

**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 Reynold’s number, sizing of pipes for non-Newtonian fluid flow, pipe network calculations, two phase flow systems – gas liquid flow, solid liquid flow, gas solid flow

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

**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, plug flow reactor, CSTR. Heterogeneous systems – analysis of rate data, fixed bed reactor, catalyst deactivation

**Text book:**

1. ‘Chemical Process Calculations’ by Raghu Raman, Elsevier Applied Science Publishers, London, New York

**Reference books:**

1. ‘Simulation of Sulphuric Acid Plant’ by C.M.Crowe
2. ‘Product and Process Design Principles- Synthesis, Analysis and Evaluation’ by Warren Sieder, J.D. Seider and Daniel R.Lewin , John Wiely and sons, New York

**IPCE-1.2.2 - AIR POLLUTION CONTROL IN INDUSTRY**

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

* a basic understanding of the fundamentals of air pollution with a background on historical perspective on air pollution
* knowledge of major air pollutants; their sources and effects (environmental, economic and health), Sampling of air pollutants and their analysis
* Insight into the dispersion of air pollution in the atmosphere
* knowledge of air pollution control equipment and their design aspects
* knowledge of various techniques to reduce the concentration of pollutants like sulphur dioxide, nitrogen oxide, organic vapors etc
* Knowledge of air pollution legislation and role of citizens in air pollution control

**Outcome:**

1. Enables student to gain knowledge about the nature, origin of air pollution and impact of the air pollution on human beings, plants and materials
2. Enables the student to learn the sampling and analysis of pollutants (Monitoring of air pollutants)
3. Enables the student to understand the updated engineering technologies to control air pollution and air pollution legislation.
4. Enables student to gain knowledge about various technologies available to control of specific air pollutants like So2, Nox , organic vapors etc.

**Syllabus:**

**Sources,** nature and type of pollutants, emission factors, meteorological factors in pollution, plume behavior and characteristics, chill index, equivalent ambient temperature, chimney design considerations, plume rise, effective stack height, element of air pollution modeling, acid rain problem,

**Health effects of pollution**, effect of plants, animals and materials, problems of air pollution in India, global problems, air pollution measurements, Ringleman’s chart.,

**Air pollution technology-I**: Sampling and analysis of particulate matter and gaseous pollutants, removal of particulate matters, principles and design of settling chambers, solid traps, cyclone separators, fabric filters and fiber filters, scrubbers and electro-static precipitators,

**Air pollution technology-II**: General methods of control and removal of sulfur-dioxide, oxides of nitrogen and organic vapors from gaseous effluents, air pollution legislation, role of citizens in air pollution control,

**Case Studies:** Madhura refinery and it’s impact on Taj Mahal, Bhopal gas tragedy, Chernobyl disaster and HPCL Visakha refinery, changes in raw materials, alternative technology for minimization of pollutants.

**Reference books:**

1. ‘Design of Pollution Control Equipment’ by Gregory Sincero and Adam Sincero
2. ‘Air Pollution’ by H.V.N. Rao, Mc Graw Hill Publications, 1998.

**IPCE-1.2.3 - ANALYTICAL TECHNIQUES**

**(Common with Mineral Process Engineering)**

**Objective**:

To understand the different types of analysis methods used in chemical industries. The course consists of both chemical and instrumental methods and also both qualitative and quantitative methods of analysis. In this course, the chemical methods of quantitative analysis include all the aspects such as: selection and sampling of materials, preparation of solutions, and analysis of various chemical raw materials and products. In instrumental methods colorimetric, spectrophotometric, spectrographic, flame emission, photo meter have been discussed.

**Outcome:**

* The student should be able to know the theory of sampling, selection and preparation of the sample.
* The student should be able to know the sophisticated instruments used for the analysis of mineral ores and chemical samples. The student should have knowledge of analysis for the ores and chemical samples.
* The student should be in a position to understand the operation of instruments like X- Ray, flame emission spectroscopy.
* The student can determine the traces of elements in the metals and alloys required for specific application.

**Syllabus:**

**Theory of sampling**, sampling of ores, minerals and coals, proximate and ultimate analysis of coal; coking index, calorific value of coal, its determination and calculation, analysis of ash,

**Wet assaying** of ores of iron, copper, lead, zinc and manganese, dry assaying process, fire saving methods for gold and silver,

**Instrumental methods of mineral investigation:** Theory and techniques of colorimetry and absorptiometry, photometer, spectrophotometers, atomic absorption spectrophotometer,

**Electrochemical methods of analysis**, Electrogravimetry methods, potentiometric titration, polarography, DTA,

**X-ray techniques**, emission of X-rays, X-rays instrumentation, X-ray diffraction, flame emission spectroscope - source, equipment and application of emission spectroscopy.

**Reference books:**

1. ‘An Introduction to Metallurgical Analysis: Chemical & Instrumental’ by S.K. Jain, Vikas Publishing House
2. A Text Book of Metallurgical Analysis’ by B.C.Agarwal & S.P.Jain, Khanna Publications.
3. ‘A Text Book of Quantitative Inorganic Analysis’ by A.I.Vogel, ELBS Edition.

**IPCE-1.2.4 - ENVIRONMENTAL BIOTECHNOLOGY**

 **(Common with Biotechnology)**

**Objectives:**

* Student to learn and understand environmental problems locally as well as global issue and consequencies.
* To learn about xenobiotics and their effect on ecosystem. To learn about biodiversity available.
* To learn about alternative and noval methods like biosorption of metals and bioleaching.

**Outcome**:

* Students have enough skills to identify the environmental problems and control measures.
* Students are in a position to plan to treat various industrial effluent using biotechnological methods

**Syllabus:**

**Environment,** types of environment, environment and development, environmental management, environmental education, principles of ecology, ecosystems, types of ecosystems, ecosystem structure and functioning, food chains, food webs, Ecological pyramids, nutrient cycling, microbial associations,

**Source, effects and control aspects of various pollutants:** Air (particulate matter, SOx, NOx, Cox, CHx, noise), water (primary, secondary and advanced treatment techniques), solids (recycling, incineration and bioconversion), global environmental problems - global warming, ozone depletion and acid rain, industrial effluent treatment- case studies of paper and pulp, tannery, pharmaceutical, fertilizer and petroleum industries,

**Biodegradation of xenobiotics**: Xenobiotic compounds in the environment, persistent compounds, degradation mechanisms,

**Bioremediation:** Bioremediation by microorganisms, bioremediation process and technologies, bioremediation measurement in the field, monitoring and efficacy of bioremediation

**Biosorption of metals**: Microorganisms and metal adsorption, factors affecting biosorption, bioreactors and biosorption, phytoremediation,

**Bioleaching:** Types of bioleaching, advantages and disadvantages of bioleaching, methods for bioleaching,

**Biodiversity:** Levels of biodiversity, value of biodiversity, global biodiversity, hotspots of biodiversity, threats to biodiversity, conservation of biodiversity,

**Environment and energy:** Biomass sources, biomass production and utilization for energy, biomass conversation routes, energy crops, biofuels, biodiesel, hydrogen production, conservation of energy, biofertilizers, biopesticides, biofilters, biosensors, biopolymers and bioplastics.

**Reference books:**

1. ’Environmental Pollution Control Engineering’ by C.S.Rao, Wiley Eastern Limited
2. ‘Waste Water Treatment: Rational Methods of Design and Industrial Practices’ by M. Narayana Rao and Amal K. Datta, Oxford & IBH Publishing Company Pvt. Ltd.
3. ‘Environmental Biotechnology: Basic Concepts and Applications’ by Indu Shekhar Thakur, I.K. International Pvt. Ltd.
4. ‘Microbial Ecology: A Conceptional Approach’ by I.M.Lunch, Oxford Black
5. ‘Environmental Biotechnology’ by Geetha Bali, APH Publishing Corporation, 2002

**IPCE-1.2.5- ELECTIVE-III**

**IPCE-1.2.5 A-ELECTIVE-III (Industrial Hazards, Safety Measures &**

**Environmental Impact Assessment)**

**Objective of the course**:

This course is designed to promote the knowledge on various important aspects of hazard analysis and EIA techniques which are mandatory for implementation by the industries. The objective include an intention that the student will get fair opportunities for obtaining employment as this particular course is having lot of demand in India and abroad.

**Outcome from the course**:

1. Now a day's industrial & occupational safety gained paramount importance for loss prevention in order to achieve considerable profit in process industries. This course significantly help the students to learn the concepts of safety, hazards, risk, occupational safety management
2. This course include an approach of conducting environmental impact assessment study and preparing reports which is mandatory for all the process industries being setup
3. The course also describes various methodologies for identification and assessment of hazards involved in handling and processing of various harmful chemicals in industries
4. Emergency preparedness plans are included in this course which enlighten the learners various aspects of planning, emergency resources, action teams and rescue operations in case of real emergencies in industries
5. The students will be knowing various statutory regulations pertaining to factories act, environmental protection act, static and mobile pressure vessel rules and other regulatory amendments to comply which can help them when they are employed in industrial sectors
6. This course may help the students for getting opportunities abroad because of huge demand of HSE engineers especially in gulf oil companies and basic chemicals manufacturing companies
7. Further learning in this field may provide self employability by way of freelanced consultancy to the industries
8. This course will provide the basis for taking up further research work in inventing new technologies for effective management of industrial hazards and occupational health

**Syllabus:**

**I. Introduction: Hazards** – chemical hazards, thermodynamic hazards, electrical & electromagnetic hazards, mechanical hazards & health hazards, **Risk** – definition, causes, potential & adverse effects, **statutory framework** – key provisions of factories act, environmental protection act, manufacture, storage & import of hazardous chemical rules, static & mobile pressure vessels rules, NFPA specifications, OSHA regulations

**II. Hazard Analysis:** Incident scenarios, residual risk, concept hazard analysis, preliminary process hazard analysis, HAZOP, Fault Tree Analysis (FTA), Event Tree Analysis (ETA), sneak analysis, Failure Mode and Effect Analysis (FMEA), Human Reliability Analysis (HRA), Cause Consequence Analysis (CCA)

**III. Safety Management Systems:** Safety policy perceptions, safety organization, safety audit techniques, **project and construction safety** – welding and cutting operations, fabrication, material handling, equipment spacing, safe plant layout procedures, storage tanks, erection and commissioning works, housekeeping methods, maintenance of storage yards, erection and maintenance of electrical panels and MCC rooms, electrical & mechanical safe guarding, **process safety management** – elements, methods of management, equipment reliability, preventive maintenance schedules, work permits, **emergency preparedness** – onsite & offsite emergency preparedness, emergency preparedness plans, site specific action plans & contingency plans, emergency facilities, rehabilitation & rescue operations, post emergency actions

**IV. Occupational Safety Management:** Occupational health perspectives, pre-employment & periodical medical examinations, diseases, causes, consequences, occupational health hazards in **various industries** – aluminium industry, asbestos, battery manufacturing, sugar, cement, coke ovens, cotton ginning, dairy, electro plating, fish canning, poultries, irrigation, lead smelting, mining, pesticides, power plants, refineries, pulp & paper industry, PVC processing, steel plants, fertilizers, sulphuric acid plants, tanneries & textiles

**V. Environmental Impact Assessment:** Introduction, comprehensive of EIA, methodology, framework of EIA, considerations, application, purpose of EIA, rapid EIA, **baseline data collection** – air pollution parameters, water pollution parameters, soil pollution, noise pollution, meteorological parameters, socio-economic studies, prediction and assessment of impacts on air environment, water environment, ecological factors, meteorological factors, flora & fauna and socio-economic conditions, environmental matrices, quantitative assessment of adverse effects, **preparation of environmental management plan** – considerations, study observations, process modifications, emission control, development of greenbelt, ecological restoration, soil conservation, rainwater harvesting, recharge of groundwater table, restoration of flora & fauna, reclamation, rehabilitation, conservation of historical monuments, review of EIA plans, modifications, **environmental impact assessment for major industries** – steel plants, refineries, power plants, bulk drugs, tanneries, mining, fertilizers and chemical industries.

**Text Books:**

1. “Hazard identification and risk assessment” by Geoff Wells, Institution of Chemical Engineers, Davis Building, UK
2. “Occupational health and safety guidelines” by Environmental Department, The World Bank, Washington DC
3. “Environmental Impact Assessment” by Larry W.Canter

**IPCE-1.2.5 B- ELECTIVE – III (Petroleum Refinery Engg - II)**

**Objective:** To know about various production processes for the manufacture of C1 to Aromatic Compounds.

To know the design aspects to be taken into consideration for the designing of various equipments used in the process.

**Outcome**: 1.Able to understand the processes and mechanisms of various production processes

 of C1 to Aromatic compounds.

 2.Able to understand the design aspects of various equipment used in the production

 processes.

**Syllabus:**

Raw materials for petrochemicals - Refinery process and petrochemical feed stocks - pyrolysis for petrochemical feed stocks - separation of individual hydrocarbons by fractionation.

Petrochemicals from C1, C2 , C3 & C4  fractions. Petrochemicals from aromatic feed stocks.

*Design of petrochemical equipment:* Pyrolysis furnace, Pyrolysis reactor (Ethane Cracking or propene cracking).

Super fractionator ( Ethyane - Ethylene, Propene - Propylene, Ethyle Benzene - styrene)

Fixed bed reactor ( Ethyle Benzene - Styrene)

Multiphase reactor ( Oxo synthesis).

*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.

**IPCE-1.2.5 C- ELECTIVE – III (Electrochemical Engineering-II)**

**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:**

1. Acquires knowledge on electrochemical ore beneficiation techniques, electroplating, electro refining and electro winning.
2. Able to work in commercial and industrial manufacturing units using electrolysis.
3. Familiarize with batteries and components like separators, binder, electrolyte, and additives used in batteries.
4. Familiarize with the characterization methods of batteries, e.g. charge/discharge cycles, overpotential, battery capacity, state of charge, state of health, impedance.
5. Familiarize with the 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.

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.

**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.

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

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

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

**IPCE-1.2.6-ELECTIVE-IV**

**IPCE-1.2.6 A-ELECTIVE-IV(Corrosion Engineering-II)**

**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 (SO2H2S).

 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 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.

 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.

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

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.

**Reference books :**

1. Mars GFontana - 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.

**IPCE-1.2.6 B-ELECTIVE-IV(Energy Engineering-II)**

**Objectives:**

The student is provided with the fundamentals of some renewable energy processes. Basic information to comprehend the various non-conventional energy systems would be gained by the student.

**Outcome:**

1. Methods to be adopted to utilize biomass as an important energy source.
2. Application of thermodynamics to convert ocean energy.
3. Possible mechanism to drawn energy from wind and other natural sources
4. Fuel cells as sources of energy.
5. New technologies to produce energy such as thermionics, thermoelectricity etc.

**Syllabus:**

**Non – Conventional & New Energy Systems and Energy Conservation Technology**

**Systems based on bio mass**

Physical and Bio mass – Definition – potential thermo – chemical methods of Bio - Conversion – Gasification – Liquefaction – Pyrolysis.

Bio-gas technology – Historical review and development in India Different designs of bio-gas jplants – Selection of a model and size – Installation – Gas collection and distribution – operation and maintenance – Properties and uses of bio-gas – Utilization of manure – National Projects for Bio – gas development – safety.(Bansal et at,chapters 10 and 11; Khandelwal and Mahdi, Chapters 3,4,5,6,7,8,9,10: Chawla,chapters 2,3,4,5,6,7 & 8).

**Fuel Cells**

Hydrogen – Oxygen Fuel Cells – carbonaceous Fuel Cells – Molten Alkali Carbonate

Cells – Electrode Reactions and kinetics. (Fuel Cells by Young).

**Energy Wind, Tidal and OTEC**

Potential in India – Origin of wind and general circulation systems of Earth – Wind direction – Wind measurement – Wind energy converters – Historical development – Power coefficient – Aerodynamic construction of a rotor blade Rotors – Wind electric generators in India – Economics of wind farm – Fundamentals and concepts of Wave energy – Ocean thermal – energy conversion (OTEC). (Bansal et at., Chapters 12,13 & 14).

**Hydrogen Energy, Methanol & Ethanol**

Hydrogen from fossil fuels from Electrolysis – Developments of various electrolytic cells – High pressure cells – Solid electrolytic systems – Hydrogen powered IC engines – Storage system – Handling and Transmission.(Journals on Hydrogen energy).

Methanol and Ethanol as Automobile fuels – Comparison with Gasoline and Diesel oil. (Journals on Hydrocarbon on processing).

**Energy Conservation Technologies:**

Principles of Energy Conservation – Optimum Energy Conservation – Industrial Energy Conservation modeling – waste heat recovery and utilization.

**Prescribed Books:**

1. Renewable Energy Sources and Conversion Technology, N.K.Bansal, Manfred Klieemann,Michael Meliss, tataMcGraw Hill, 1990.
2. Bio Gas Technology, A practical hand book Vol 1, K.C.Khandelwal and S.S.Maholi, TataMcGraw Hill, 1986.
3. Advances in Bio Gas Technology: O.P.Chawla,publications and Information Division, Indian council of Agricultural Research,New Delhi, 1986.
4. Alternative Energy Sources: R.H .Taylor, Adam Hilger Ltd.,Brister.
5. Fuel cells, Vols.I & II: Reinhold publishing Crop.,New York.
6. International journal of hydrogen Energy, Vol.5, No. I, 1980 pages 1- 84: No.2, pages 119-129; pages 151-203; No.5. Pages 527 – 534 & 539 – 553; No.6, Pages 611 – 625.
7. Hydro Carbon Processing Vol. 58, May 1979 pages 127 – 138:Vol. 59, Feb. 1980, pages 72–75.
8. Handbook of Industrial Energy Conservation, David Hu, S., Van Nostrand Reinhold Company pages 73 – 133, 149-199, 297-327.

**IPCE-1.2.6 C-ELECTIVE-IV (Reaction Engineering-II)**

**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.