Petroleum Refining Engineering

1.1 Course Number: CH281

1.2 Contact Hours: 3-0-0 Credits: 9

1.3 Semester -offered: 2nd Year- even

1.4 Prerequisite: Not Required

1.5 Syllabus Committee Member: Dr M S Balathanigaimani, Dr Vivek Kumar

2. **Objective:** The course on Petroleum Refining Engineering is to deal various refinery activities starting from the crude pretreatment to the bottom of the barrel upgradation. The concept of straight-run and blended products and their respective production procedures will be discussed at a length.

3. **Course Content:**

Unit wise distribution of content and number of lectures

Unit	Topics	Sub-topic	Lectures
1	Crude Oil: Pretreatment & separation	Crude oil properties, Crude desalting, Crude oil distillation processes	4
2	Refining Processes	Thermal Cracking Processes, Thermal conversion processes, Visbreaking and design variables of visbreaking, Coking: fluid coking, flexicoking, delayed coking and hardware Considerations	8
3	Catalytic Cracking	Caltalytic cracking processes, Catalytic conversion processes, Fluid catalytic cracking with special reference to catalyst and reactor design configurations, Residual FCC	6
4	Hydro-Processes	Hydroconversion processes, Hydrocracking: catalyst and reactor design configurations, Hydrogen production, purification and management, Hydrotreating and hydrodesulphurization processes, catalyst, reactor design configuration	10
5	Light-end upgradation processes	Reforming: catalysts and processes, Alkylation, Isomerization, Etherification	8
6	Auxiliary processes & Additives	Gas treating and sulfur recovery, Blending and additives	4
		Total	**40**

4. **Readings**

4.1 Text Books:

1. Gary, J. H., Handwerk, G. H. and Kaiser, M. J., *Petroleum Refining Technology and Economics*, 5th Ed., CRC Press, New York, 2007.
2. Jones, D. S. J. and Pujado, P. P., *Handbook of Petroleum Processing*, Springer, New York, 2006.

4.2 Reference Books:

1. Meyers, R. A., *Handbook of Petroleum Refining Processes*, 2nd Ed., McGraw Hill, New York, 1996.
2. Mark, H., Othmer, D. F., Overberger, C. G. and Seaborg, G. T. (Eds.), *Kirk-Othmer's Encyclopedia of Chemical Technology*, *Petroleum Technology*, Vol. 17, 3rd Ed., Wiley, New York, 1982.

5. **Outcome of the Course:** The students will have a deep understanding about handling of straight-run products from a crude distillation tower, various products which can be produced from a refinery along with their respective properties, separation, conversion and upgradation processes involved in the refinery.

Fluid Flow Operations

1.1 Course Number: CH222
1.2 Contact Hours: 2-1-0 Credits: 8
1.3 Semester-offered: 3rd
1.4 Prerequisite: Basic concept of Fluid Mechanics

2. **Objective:** The objective of this course is to enable student to acquaint with incompressible flows in pipes and channels and to familiarize with flow of compressible fluids. This course will also help students to understand transportation and metering of fluids.

3. **Course Content:**

Unit wise distribution of content and number of lectures

Unit	Topics	Sub-topic	Lectures
1	Introduction	Pipe, fittings and valve	2
2	Bernoulli Equation	Bernoulli equation and its correction effect for solid boundaries	2
3	Incompressible Flow in Pipes and Channels	Shear stress, skin friction, laminar flow, Hagen–Poiseuille equation, laminar flow of non-Newtonian fluid, turbulent flow, universal velocity distribution, friction from changes in velocity and direction, pressure drop calculations	8
4	Flow of Compressible Fluids	Definitions and basic equations, Isentropic flow through nozzles, Adiabatic friction flow, Isothermal friction flow	5
5	Transportation of Fluids	Pumps (positive displacement pumps, centrifugal pump etc), Compressors, etc	7
6	Metering Devices	Venturimeter, Orificemeter, Rotameter and Pitot tube etc	4

4. Readings

4.1 Text Books:

1. Unit Operations of Chemical Engineering by Warren McCabe, Julian Smith, Peter Harriott, 7th Edition, McGraw-Hill
2. Unit operations by G.G. Brown, CBS Publisher

4.2 Reference Books:

1. An Introduction to Fluid Mechanics by Fox and Mcdonald, 7th Edition, John Wiley
2. Fluid Mechanics by Frank M White, 6th Edition, McGraw-Hill

5. Outcome of the Course: Upon completion of this course, student will be able to identify and understand the basics of incompressible flow and fluid friction in pipes. The student will also understand the basic applications of Bernoulli equation and learn about metering devices. They also have clear idea on transportation of fluids and its practical applications.

Mass and Energy Balances

1.1 Course Number: CH171
1.2 Contact Hours: 2-1-0 Credits: 8
1.3 Semester-offered: 3rd
1.4 Prerequisite: Not Required

2. **Objective:** To introduce Chemical Engineering students the basic principles and calculation techniques used in the chemical industries and to acquaint them with the fundamentals of the material and energy balances as applied to Chemical Engineering.

3. **Course Content:**

Unit wise distribution of content and number of lectures

Unit	Topics	Sub-topics	Lectures
1	Introduction	Fundamentals of engineering calculations, Process parameters and variables, Fundamentals of material balances, Basic features of chemical process, Rates, Pressure and Temperature of flow process, Unit systems and dimensions	2
2	Non-reactive Systems	Material balance calculations for single units without reactions, Material balance calculations for multiple units without reactions	3
3	Fundamentals of Reactive Systems	Material balance calculations for single units with a single reaction, Material balance calculations for single units with multiple reactions, Material balance calculations for multiple units with reactions, Introduction to combustion reactions, Material Balances for systems with recycle, Bypass and purge	5
4	Basic Principle of Compressible System	State Equation of Ideal Gas and Calculation, State Equation of non-Ideal Gas and Calculation	2
5	Basic Principle of Multi-Phase System	Phase equilibrium, Equilibrium Laws, Humidity and Saturation, Psychrometric chart, Process of phase change: Condensation and vaporization	3
6	Energy Balance in Non-Reactive Systems	Introduction to energy balances, Standard heat of formation, the mechanical energy balance, Enthalpy balances without reaction in single phase, Energy balance with multiple streams without reaction, Energy balance on heat of solution, Energy balance in	7

		nonreactive phase change processes, Estimating latent heats	
7	Reactive Systems	Energy balance with heat of reaction, Energy balance with heat of combustion	3
8	Transient Processes	Unsteady State Material Balances, Unsteady State Energy Balances	3

4. **Readings**

4.1 Text Books:

1. Richard M. Felder, Ronald W. Rousseau, “Elementary Principles of Chemical Processes” 4th Edition”, Wiley, 2015
2. David M. Himmelblau, James B. Riggs, “Basic Principles and Calculations in Chemical Engineering”, Pearson Education India; 8th Edition, 2015

4.1 Reference Books:

1. Mark E. Schlesinger, “Mass and Energy Balances in Materials Engineering”, Pearson, 1995

5. **Outcome of the Course:** This course will enable students to learn the basics of material and energy balances and their applications in chemical and process industries by using examples primarily based on chemical engineering operations.

Solid-Fluid Mechanics and Mechanical Operations

1.1 Course Number: CH223
1.2 Contact Hours: 2-1-0 Credits: 8
1.3 Semester-offered: 3rd
1.4 Prerequisite: Basic Fluid Mechanics

2. Objective: The course covers the key features of industrially used Solid-fluid separation/purification operations mechanically. It also covers the operations like Agitation, mixing, storage and conveying of fluids and solids.

3. Course Content:

Unit wise distribution of content and number of lectures

Unit	Topics	Sub-topic	Lectures
1	Introduction	Relevance of fluid-particle mechanics and processing operations in chemical process industry	1
2	Flow Past Immersed Bodies	Particle mechanics (motion of particle in fluid), Motion in gravitational and centrifugal field, Settling velocity— stroke's law, criterion for settling regime, Free settling, Hindered settling	2
3	Flow through bed of particles	Fluid flow through packed beds of particles- Ergun equation, Kozeny- Carman equation, Fluidization: Minimum fluidization velocity, Types of fluidization, Liquid- solid and gas-solid systems	4
4	Agitation and Mixing	Purposes of agitation, Devices to produce agitation, Agitated vessels, Power consumption of agitators, Blending and mixing—suspension of solid particles, Correlations for suspension, Power consumption, Mixers for non-cohesive and cohesive solids, Mixing effectiveness	4
5	Filtration and separation	Types of filters- pressure filters, rotary drum filters, Principles of flow through filter cakes and medium, Filter media – pressure drop through filter cake, Compressible and Incompressible filter cakes, Filter medium resistance, Constant-pressure filtration, Constant rate filtration, Cake resistance, Clarifying filters – principles of clarification, Crossflow filtration, Membrane filtration, Selection of filtration equipment, Sedimentation – free, fine and coarse particle, Gravity sedimentation processes,	7

		Centrifugal sedimentation processes, Principle of sedimentation in a centrifugal field, Centrifugal decanters, Gas cyclone and hydrocyclones, Cyclone geometry, Sizing and selection of hydrocyclones	
6	Solid particle characterization and size reduction	Particle shape, size and properties, Specific surface of mixture, Size distribution, Determination of mean particle size, Methods of particle size measurement, Screen analysis, Size measurements with fine particles, Particle size reduction: characteristics of comminuted products, Energy and power requirements in comminution, Crushing laws and work index, Selection of appropriate machine—crushers, grinders, ultrafine grinders, Equipment design and operation, Energy consumption, Particle size enlargement	6
7	Storage of solids	Bin, silos, hoppers etc., Design of Silos for flow, Flow patterns, Flow problems	1
8	Solid Transportation	Pneumatic and hydraulic transportation, State Diagram of pneumatic conveying, Basic components of a pneumatic conveying system, Screw feeders and screw conveyors	2

4. **Readings**

4.1 Text Books:

1. Gupta, S. K., Momentum Transfer Operations, Tata McGraw Hill, New Delhi, 1979.
2. McCabe, W. L., Smith, J. C. and Harriot, P., Unit Operations of Chemical Engineering, 5th Ed., McGraw Hill, New York, 1993

4.2 Reference Books:

1. Alan.S.Foust, Leonard A. wenzel, Courtis W.Clump, Lousi Maus, L.Bryce Andersen (Ed) Principles of Unit operations, WILEY, 2011.
2. Coulson &Richardson's Chemical Engineering Volume 2, Particle Technology and separation processes, Butterworth Heinmann, 2002.

5. **Outcome of the Course:** After the successful completion of the course the students will be able to understand the principles of flow through packed beds and fluidized beds, agitated vessels and mixtures. They will also be acquired knowledge about particulate solids flow and separation through fluid mechanics and improve ability to select suitable industrial equipment for separation of solid-solid, liquid-solid, gas-solid systems

Materials Science

1.1 Course Number: CH211
1.2 Contact Hours: 3-0-0 Credits: 9
1.3 Semester-offered: 4th
1.4 Prerequisite: Basic Physics, Physical Chemistry, Mathematics, and Thermodynamics

2. Objective: The course objective is to understand how nature of atomic bonding influences the structure of the materials, and how structure and processing influence the properties of the materials. To understand perfect and imperfect crystalline structures and its measurement techniques. To understand inter-relationship between the microstructure and materials properties. To understand how phase diagram can be utilized to design the thermal processing steps to cause the materials to undergo phase transformations in a controlled manner to develop a desired microstructure and thereby examine the macroscale properties of the materials. To understand origins of mechanical behavior of the materials such as their stress-strain response, elasticity, plasticity, creep, viscoelasticity, and fatigue, and applying this understanding for engineering applications. Understand origins of electronic properties of the materials, and their applications in areas related to energy such as semiconductor device engineering, photovoltaics, and catalysis. To understand the basic operational principles of some material characterization techniques for mechanical, structural, and electronic characterization. Understand electrochemical interactions between materials in different phases and their applications in corrosion engineering.

3. Course Content:

Unit wise distribution of content and number of lectures

Unit	Topics	Sub-topic	Lectures
1	Structure of material	Nature of interatomic bondings and crystallographic description of the crystalline materials	5
2	Measurement Techniques	XRD characterization of materials	3
3	Defects	Imperfections in crystalline materials and alloys. Point, line, and plane defects, Diffusion in materials	8
4	Phase Diagram	Binary phase diagrams in solid-solid systems and microstructures, Phase transformations, Steel making	8
5	Mechanical properties of materials	Elasticity, anelasticity, plasticity, viscoelasticity, creep, fatigue, fracture. Engineering applications	6

6	Electronic properties of materials	Metals and semiconductors. Origin and applications in device engineering, catalysis, and electrochemical engineering	5
7	Applications	Electrochemical interactions and corrosion engineering.	3
		Polymers and amorphous materials with their engineering applications	2

4. **Readings**

4.1 Text Books:

1. V. Raghavan, Materials Science and Engineering: A First Course, 6th Edition, Prentice Hall India.
2. William J. Callister and David G. Rethwisch, Materials Science and Engineering: An Introduction, 10th Edition, , Wiley

5. **Outcome of the Course:** The students will be able to identify the periodic structures in crystalline materials and correlate it with the XRD data. The students will also be able to find the nature of the phase under given thermodynamic conditions and calculate their relative abundance in a solid solution from its given phase diagram. They can predict the microstructure and mechanical behavior in iron carbon and other binary systems from the given thermal history and phase diagram. Qualitatively draw the stress strain behavior of the materials given their microscopic details such as nature of bonding, structure etc. and design engineering materials for a given mechanical application.

Fundamental of Polymers and Petrochemicals

1.1 Course Number: CH191
1.2 Contact Hours: 2-0-0 Credits: 6
1.3 Semester-offered: 4th
1.4 Prerequisite: Not Required

2. Objective: The course will provide basic knowledge about the polymers and petrochemicals. The classification, basic properties and utility of these materials will be discussed in the course. The method of polymer preparation, thermal and mechanical properties along with processing of polymers will be taught as a part of the course. Several commercially important polymers such as polyurethane, polyvinyl chloride, polyethylene, polypropylene and polyester commercial scale synthesis, processing and utilization will be discussed during the course.

3. Course Content:

Unit wise distribution of content and number of lectures

Unit	Topics	Sub-topic	Lectures
1	Introduction to Petrochemicals	Introduction to petrochemicals, classification, raw materials, originating source	3
2	Manufacturing process of Chemicals from methane	Manufacturing process of methanol, Acetic acid, Vinyl Acetate, Poly Vinyl Acetate	5
3	Manufacturing process of chemicals from ethylene	Manufacturing process of Ethylene, Low density polyethylene, High density polyethylene, Vinylchloide monomer, Polyvinylchloride, Ethylene oxide and Ethylene glycol	8
4	Other Processes	Manufacturing process of styrene, Polystyrene, Styrene butadiene rubber	4
5	Introduction to Polymers	Classification of polymer, molecular weight, mechanical properties, thermal properties, monomer	4
6	Category of polymers	Conducting polymers, biopolymers, liquid crystalline polymer, shape memory polymers, hyper branched polymer & dendrimers	6
		Structure-property correlation in polymers	4

7	Methods for polymer synthesis	Step growth, chain growth, radical, leaving polymerization	4
		Polymer properties, rheology and processing tools	3

4. **Readings**

4.1 Text Books:

1. L.H. Sperling, Introduction to Physical Polymer Science, 4th Edition
2. Fred W. Billmeyer, Jr., Textbook of Polymer Science 3rd Ed., Wiley, New York, USA, 1984.
3. G. Odian, Principles of Polymerization, 3rd Ed., Wiley, New York,1991
4. F. Rodriguez, Principles of Polymer Systems, 5th Ed, McGraw Hill, New York, 2003.
5. Manas Chanda, Introduction to polymer science and chemistry, CRC Press

4.2 Reference Books:

1. Werner Pauer , Polymer Reaction Engineering of Dispersed Systems.

5. **Outcome of the Course:** The students will understand different petrochemical products and their manufacturing processes. The students will also be able to understand different categories of polymers, their synthesis and properties.

Fire, Safety and Hazard Analysis

1.1 Course Number: CH201
1.2 Contact Hours: 2-0-0 Credits: 6
1.3 Semester-offered: 4th
1.4 Prerequisite: Not Required

2. Objective: Introduction to the concept of process safety in Industry and understanding the hazard of fire and its analysis.

3. Course Content:

Unit wise distribution of content and number of lectures

Unit	Topics	Sub-topic	Lectures
1	Industrial Safety and Loss	Industrial safety and loss trends, loss prevention, Development of safety programmes in process industry, Accident causation: Heinrich-Domino theory, Human error model, Petersen's accident/ incident model, Epidemiological models, System models, Multiple causation.	4
2	Effects on Health	Toxicology, Effects on health, Dose-Response, Threshold Limit Value -TLV, etc.	5
3	Theory of combustion and explosion	Vapor clouds, Flash fire, Jet fires, Pool fires, Unconfined vapor cloud explosion, Shock waves, Auto-ignition, Boiling liquid expanding vapor explosion, Production of fire, Fire development, Severity and duration, Classification of fires, causes, detection, preventive measures, Inertisation. Explosions: Mechanism, causes, characteristics, preventive and control measures.	6
4	Risk Analysis and Management	Hazard Identification (HAZID), Occupational hazard, Preliminary Hazard Analysis (HAZAN), Hazard and operability study (HAZOP), Hazard control: Engineering and management controls, Assessment of the frequency of incidents including Fault Tree Analysis (FTA) and Event Tree Analysis (ETA), Risk analysis techniques: matrices, qualitative, semi-quantitative, Quantitative	8

		Risk Analysis (QRA), Bow Tie diagrams, Layers of Protection Analysis (LOPA), Risk analysis and management, Systems safety management: Management task, Managerial roles and skills, Management by objective	
5	Case-studies	Case studies of safety and hazard assessment in different industries (including O & G industry), Disaster management planning, Design for safety, maintenance and fault diagnosis	5

4. **Readings**

4.1 Text Books:

1. Crowl, D.A. and Louvar, J.F., "Chemical Process Safety: Fundamentals with Applications", Prentice Hall, Inc.
2. T.A. Kletz, 'HAZOP & HAZAN', CRC Press.

4.2 Reference Books:

1. Wills, G.L., Safety in Process.
2. Lees, F.P., Loss Prevention in Process Industries, Volume I & II, Butterworth Heinemann.
3. Pandey, C.G., Hazards in Chemical Units: a Study, Oxford IBH Publishing Co., New Delhi.

5. **Outcome of the Course:** Students will gain sufficient understanding about fire hazards in industry. They will learn how to analyze those and conduct assessment of risk. Further, they will have the experience to carry out simple hazard analysis studies adequately, recognizing the limits to that understanding, and appreciate the standards required to conduct various process safety analysis.

Fundamentals of Electronics Engineering

1.1 Course Number: EC111
1.2 Contact Hours: 3-1-2 Credits: 13
1.3 Semester-offered: 4th
1.4 Prerequisite: Not Required

2. Objective: To introduce the students to the basics of both theoretical and practical aspects of broader area of Electronics Engineering.

3. Course Content:

Unit wise distribution of content and number of lectures

Unit	Topics	Sub-topic	Lectures
1	Circuit Analysis Techniques and Theorems	Nodal, Mesh, Superposition, Thevenins theorems, Nortons theorems, Transient analysis of capacitive and inductive circuits, Sinusoidal steady state analysis of circuits containing resistors, capacitors, inductors, Transfer functions	12
2	Electronic Devices	Semiconductors, Diodes and diode circuits, BJT, MOSFETs, Amplifiers, IC fabrication, Operational amplifier circuits, Waveform generators	12
3	Number System	Number system, logic gates, logic minimization, combinational circuits	8
4	Programmable Arrays	Field programmable gate arrays (FPGAs); Flipflops, sequential circuits, counters, shift registers, data converters (DAC, ADC)	8

4. **Readings**

4.1 Text Books:

1. Charles K. Alexander, Matthew N.O. Sadiku, *Fundamentals of electrical circuits*, McGraw-Hill , 5th Edition 2013
2. S. Sedra and K. C. Smith, *Microelectronic Circuits*, Oxford University Press , 6th edition
3. Leach , Malvino, Saha, *Digital Principles and Applications*, McGraw Hill Education , 8th edition

4.2 Reference Books:

1. E. Hughes, *Electrical and Electronic Technology*, PEARSON , 2010
2. Charles K. Alexander, Matthew N.O. Sadiku, *Fundamentals of electrical circuits*, McGraw-Hill , 5th Edition 2013
3. William H. Hayt , Jack Kemmerly , Steven M. Durbin, *Engineering Circuit Analysis*, McGraw-Hill , 8th Edition 2013
4. David. A. Bell, *Electronic Devices and Circuits:*, Oxford University Press, 5th Edn. , 5th edition
5. Boylestad, Robert L., Louis Nashelsky, *Electronic Devices and Circuit*, Pearson , 11th edition

5. **Outcome of the Course:** The student will learn about fundamentals of Electronics Engineering. They will also be able to learn and use circuit analysis techniques.