Semester IV

Unit Operations - II

1.1 Course Number: CE206
1.2 Contact Hours: 3-1-0 Credits:11
1.3 Semester- offered: 2nd Year –Even
1.4 Prerequisite: Diploma level Mathematics and Physics
1.5 Syllabus Committee Members: Dr. Bhaskar Jyoti Medhi, Dr. Anil Kumar Varma, Dr. Arun Kumar

2. Objective:

To understand the fundamentals of heat transfer mechanisms in fluids and solids and their applications in various heat transfer equipment in process industries.

3. Course Content:

Unit-wise distribution of content and number of lectures

Unit	Topics	Sub-Topic	Lectures
1	**Introduction**	Heat and Modes of heat transfer: Conduction, Convection, Radiation, Concept of steady state and unsteady state heat transfer, Analogy between flow of heat and electricity.	4
2	**Conduction**	Thermal conductivity, Fourier's law of heat conduction, Steady state equation, Heat flow equation for composite walls, Composite cylinders, Spheres, Insulation and insulating materials, Critical insulation thickness.	8
3	**Convection**	Nature of heat convection, Dimensional analysis and significance of various dimensional groups, Forced convection (No derivation), Free convection (No derivation)	8
4	**Thermal Radiation**	Nature of thermal radiation, Absorption, Transmission, Reflection and Emission of radiation, Emissive power of black body, Plank's distribution, Total emissive power, Stefan-Boltzman law, Emissivity, Kirchoff's law, Black body, Wien's displacement law.	6
5	**Heat Exchangers**	Introduction, Types of Heat Exchangers, Overall Heat Transfer Coefficient, Construction and Description of Various Types of Heat Exchangers, Logarithmic Mean Temperature Difference, LMTD for Parallel and Counter Current Heat Exchangers.	8
6	**Boiling and Condensation**	Interface, Bubble and Film boiling, Boiling regime, Concept of condensation, Types of condensation: Drop wise and Film wise condensation.	6
TOTAL			**40**

4. Readings:

4.1 Textbooks:

1. J. P. Holman, Heat Transfer, McGraw - Hill.
2. B. K. Dutta, Heat Transfer, Prentice Hall of India.

4.2 Reference Books:

1. D.Q. Kern, Process Heat Transfer, Tata McGraw - Hill.
2. W. L. McCabe, J. Smith and P. Harriot, Unit Operations of Chemical Engineering, McGraw-Hill.

5. Outcome of the Course:

Students completing the course will be able to:

1) Understand basic laws associated with conduction, convection and radiation and its applications.
2) Analyze problems involving steady heat conduction in simple geometries.
3) Understand the concept of convective heat transfer and to analyze the problems involving heat transfer coefficients for natural and forced convection
4) Analyze heat exchanger performance using LMTD and use it for parallel or counter flow
5) Recognizer various type of heat exchanger working principle, and basic geometries of heat exchanger.
6) Determine the overall heat transfer coefficient for a heat exchanger.
7) Understand the concept of boiling and condenser.

Unit Operations - III

1.1 Course Number: CE207
1.2 Contact Hours: 3-1-0 Credits: 11
1.3 Semester-offered: 2nd Year –Even
1.4 Prerequisite: Diploma level Physics & Mathematics
1.5 Syllabus Committee Members: Dr. Bhaskar Jyoti Medhi, Dr. Anil Kumar Varma, Dr. Arun Kumar

2. Objective:

The purpose of this course is to introduce the students with the laws of diffusion; convective mass transfer, inter phase mass transfer and mass transfer coefficients, mass transfer theories. This course will also provide proper understanding and application of mass transfer such as absorption, humidification, drying and crystallization.

3. Course Content:

Unit-wise distribution of content and number of lectures

Unit	Topics	Sub-Topic	Lectures
1	**Introduction to Mass Transfer: Diffusion**	Introduction to Mass Transfer Operations and Classifications, Diffusion: Types of diffusion, Fick's Law of diffusion, Measurement and estimation of diffusivity, Molecular diffusion in solids: Molecular, Knudsen & Surface diffusion. Inter-phase mass transfer, Mass transfer coefficients, Convective mass transfer, Dimensionless groups in mass transfer and their significance, Analogy between Momentum, Heat and Mass transfer, Diffusion between phases, Theories of Mass Transfer: Film Theory, Penetration theory, Surface renewal theory.	12
2	**Absorption**	Absorption: Application, Types; Choice of solvent, Equipments, Different materials used in absorption column.	6
3	**Humidification**	Humidity: Absolute, Relative, Percentage; Dew point, Dry bulb and Wet bulb temperature, Adiabatic saturation temperature, Cooling towers: Principle, Classification.	6
4	**Drying**	Principle, Equilibrium in drying, Definitions of moisture content, Mechanism of batch and continuous drying, Rate of batch drying: drying curve, Time required for drying, Classification and selection of industrial dryers.	8
5	**Crystallization**	Principle, Classification, Solid-liquid phase	8

		equilibrium, Nucleation and crystal growth, Melt crystallization, Batch crystallization, Crystallization equipment.	
TOTAL			**40**

4. Readings:

4.1 Textbooks:

1. R. E. Treybal, Mass Transfer Operations, McGraw – Hill, International Edition.
2. W. L. McCabe, J. Smith and P. Harriot, Unit Operations of Chemical Engineering, McGraw-Hill, International Edition.

4.2 Reference Books:

1. C. J. Geankoplis, Transport Processes and Unit Operations, Prentice Hall, India.
2. B.K. Dutta, Principles of Mass Transfer and Separation Processes, Prentice Hall of India.

5. Outcome of the Course:

Students completing this course will be able to explain the

1) Principles of molecular diffusion, determine mass transfer rates using Fick's Law and estimate diffusion coefficients for liquids and gases, analogy and theories of mass transfer, concept of inter phase mass transfer.
2) Basic principles and application of gas absorption, understanding of various Equipments to carryout absorption.
3) Different terms and definition of humidification process, different type of cooling tower.
4) Different terms and definition of drying, calculate the drying time and equipments to carryout drying (batch and continuous).
5) Theories of crystallization yield of crystals and different types of crystallizers.

Petroleum Refinery Operations

1.1 Course Number: CE208
1.2 Contact Hours: 3-0-0 Credits: 9
1.3 Semester- offered: 2nd Year –Even
1.4 Prerequisite: Diploma level Chemistry and Unit Operations II & III
1.5 Syllabus Committee Members: Dr. Bhaskar Jyoti Medhi, Dr. Anil Kumar Varma, Dr. Arun Kumar

2. Objective:

Petroleum sector plays the most vital role for keeping the wheels of economic development rolling and chemical engineers mainly run the petroleum industry. Knowing the sources of crude petroleum, extraction of the crude petroleum, its refining to the useful petro-products and efficient transport to the end users through network are important tasks to the petroleum or chemical engineers. This course intends to form the foundation of the chemical engineers on all the above-mentioned basic fields of petroleum from extraction to the safe end use where refining is the most challenging. The course puts major thrust on all the techniques/processes of petroleum refining encompassing selection of the mass/heat transfer devices, their operation and basic design. The course also covers the feed stocks of petrochemical industries and manufacture important petrochemicals.

3. Course Content:

Unit-wise distribution of content and number of lectures

Unit	Topics	Sub-Topic	Lectures
1	**Introduction to Petroleum Industry**	Overview of Indian petroleum industry, Crude oil: Origin, Composition, Characteristics; Exploration Methods, Search for crude oil, Scientific methods for petroleum survey, Introduction to rigs.	6
2	**Quality Control of Petroleum Products**	Classification of laboratory tests: Distillation, Vapour pressure, Flash and Fire points, Octane number, Performance number, Cetane number, Aniline point, Viscosity index, Calorific value, Smoke point, Char value, Viscosity, Viscosity index, Penetration test, Cloud and Pour points, Drop point of grease, Melting and Settling points of wax, Softening point of Bitumen, Induction period of gasoline, Thermal stability of jet fuels, gum content, Total Sulphur, Acidity and Alkalinity, Copper Strip Corrosion Test, Silver-Strip Corrosion Test for ATF, Ash, Carbon Residue (Conradson method, Ramsbottom method), Colour, Density and Specific gravity.	10
3	**Petroleum Products**	Composition, Properties & Specification of LPG, Naphthas, Motor spirit, Kerosine, Aviation Turbine Fuels, Diesel Fuels, Fuel Oils.	6
4	**Crude Oil**	Desalting of crude oils, Atmospheric distillation of crude oil,	12

	Distillation, Thermal and Catalytic Conversion Process	Vacuum distillation of atmospheric residue. Products of fractional distillation of crude oil and their boiling ranges. Thermal Cracking Reactions, Thermal Cracking, Visbreaking (Conventional Visbreaking and Soaker Visbreaking), Coking (Delayed Coking, Fluid Coking, Flexicoking), Fluid catalytic cracking; Comparison between thermal and Catalytic cracking, Hydrocracking, Hydrotreating, Reforming, Isomerization, Alkylation: Hydrofluoric acid process, Sulphuric acid process; Polymerization.	
5	**Introduction of Petrochemical Industry**	Definition, History, Raw materials for petrochemicals, Characteristics of petrochemical Industry, Major petrochemical producers in India, different petrochemical products and their uses.	6
TOTAL			**40**

4. Readings:

4.1 Textbooks:

1. W.L. Nelson, Petroleum Refinery Engineering, McGraw Hill, New York.
2. B.K. B Rao, Modern Petroleum Refining Processes, Oxford & IBH *Publishing.*

4.2 Reference Books:

1. B.K. B Rao, A Text on Petrochemicals, Khanna Publishers.
2. S. Maity, Introduction to Petrochemicals, Oxford and IBH Publishing.

5. Outcome of the Course:

On completion of this course, students will be able to

1) Understand the worldwide scenario of petroleum refinery, growth prospects, origin of crude oil, their characteristics and future trends.
2) Demonstrate the comprehensive understanding of classification, properties and uses of various refinery products.
3) Develop the knowledge of different refining operations like pretreatment of crude oil, atmospheric and vacuum distillation, cracking operations.
4) Study of different advance processing techniques like hydro cracking, visbreaking, isomerization, polymerization along with process flow sheet and descriptions.
5) Identify and suggest safe practices in operations of refineries and petrochemical complexes.

Chemical Engineering Thermodynamics

1.1 Course Number: CE209
1.2 Contact Hours: 3-0-0 Credits:9
1.3 Semester-offered: 2nd Year –Even
1.4 Prerequisite: Class 12th level Mathematics & Physics
1.5 Syllabus Committee Members: Dr. Bhaskar Jyoti Medhi, Dr. Anil Kumar Varma, Dr. Arun Kumar

2. Objective:

i) To introduce the basic concepts of thermodynamics; apply the laws of thermodynamics.

ii) To generate the ability to differentiate different forms of energy i.e., heat and work.

iii) To apply first law of thermodynamics to closed and flow systems.

iv) To apply the second law of thermodynamics, spontaneity and irreversibility in nature.

v) To introduce thermodynamic properties of fluid and performance of thermal systems used in industry.

vi) To learn basic concepts of chemical reaction equilibrium.

3. Course Content:

Unit-wise distribution of content and number of lectures

Unit	Topics	Sub-Topic	Lectures
1	**Basic concepts and definition**	Definition of System, Surrounding, closed systems, and open system; Properties: (extensive and Intensive), Characteristics of properties (point and path function), and its representation on a property diagram; Units of measurements: Heat, work and energy. Equilibrium: Thermal, Mechanical, Chemical, Thermodynamic; Zeroth Law of Thermodynamics and temperature, the ideal gas temperature scale. Reversible and Irreversible processes; Different types of process and their representations.	8
2	**First Law of Thermodynamics and its Applications**	Definitions and calculations: Work Transfer, Different modes of work, Displacement Work for various processes, Heat Transfer, Specific heat, Latent heat, Joule's experiment, Introduction of internal energy as a thermodynamics property, Introduction of enthalpy as a thermodynamic property; Definition of specific heats and their use in calculation of internal energy and enthalpy	10

		with emphasis on ideal gases. Application of First Law to control mass: Work done and heat transfer in various types of elementary processes; Application of First Law to control volumes; Nozzle, Diffuser, Compressor, Turbine, Throttling device, Heat Exchanger. (Only steady flow need be considered).	
3	**Second Law of Thermodynamics and its Applications, Concept of Entropy**	Limitations of first law of thermodynamics; Cyclic heat engine; Energy reservoirs; Refrigerator and Heat Pump; Kelvin-Plank statement and Clausius statement of second law; Reversibility and Irreversibility; Carnot Cycle and Carnot Theorems; Concept of entropy; Entropy and Disorder; Entropy changes in various processes, Entropy Principle and its application,	6
4	**PVT behaviour of pure fluids**	Equation of states and concept of ideal gas, Equations of states for real gases, Critical properties, corresponding state, Real gas and compressibility factor, Virial equations, Cubic equations, Generalized correlations and Eccentric factor,	6
5	**Homogenous Mixtures**	Thermodynamics properties of homogenous mixtures, Property relationships for systems of variable compositions, Partial molal properties. Fugacity and fugacity coefficient, Clapeyron's equations, Residual properties. Excess properties, Activity and activity coefficients.	6
6	**Chemical Reaction Equilibrium**	Reaction coordinate, Criteria of chemical reaction equilibrium, Standard free energy change and reaction equilibrium constant, Evaluation of reaction equilibrium constant, Effect of temperature on equilibrium constant, Phase rule for reacting and non-reacting system,	6
TOTAL			**42**

4. Readings:

4.1 Textbooks:

1. J. M. Smith, H C Van Ness, Introduction to Chemical Engineering Thermodynamics, McGraw Hill Edition.
2. K. V. Narayanan, Chemical engineering Thermodynamics, Eastern Economy Edition.

4.2 Reference Books:

1. Y. V. C. Rao, Engineering Thermodynamics, University Press.
2. P. K. Nag, Basic and Applied Thermodynamics, Tata McGraw Hill Edition.

5. Outcome of the Course:

Students completing this course will be able to

1) Understands the laws of thermodynamics and their applications.
2) Calculate the thermodynamic properties using residual properties.
3) Estimate the thermodynamic properties of substances for ideal and real mixture.
4) Evaluate the equilibrium constant and Gibb's free energy change of a chemical reaction by applying criterion of equilibrium. Analyze the effect of change in temperature, pressure and composition on equilibrium conversions for chemical reactions, Phase rule for reacting and non-reacting system.

Chemical Reaction Engineering

1.1 Course Number: CE210
1.2 Contact Hours: 3-0-0 Credits: 9
1.3 Semester-offered: 2nd Year –Even
1.4 Prerequisite: Diploma level Mathematics & Chemistry
1.5 Syllabus Committee Members: Dr. Bhaskar Jyoti Medhi, Dr. Anil Kumar Varma, Dr. Arun Kumar

2. Objective:

i) To understand and analyze reaction rate data to determine rate laws, and to use them to design chemical reactors.

ii) To learn about different ideal reactors and their reacting schemes in order to choose the most appropriate reactor for a given need.

3. Course Content:

Unit-wise distribution of content and number of lectures

Unit	Topics	Sub-Topic	Lectures
1	**Basics of Chemical Reactions & Kinetics of Homogeneous Reactions**	Scope and importance of Chemical Reaction Engineering, Chemical Kinetics, Classifications of Chemical Reaction, Rate of Chemical reaction: Reaction rate on various basis, Factors affecting the rate equation, Rate Expression, Concentration Dependent term, Rate constant, Reaction Mechanism, Elementary and Non-Elementary Reaction, Molecularity and Order of reaction, Temperature Dependent term of rate equation: Arrhenius law, Activation Energy.	10
2	**Batch Reactor Data**	Constant volume batch reactor, Integrated rate equation for different order reaction, Half-life Method.	8
3	**Ideal Reactors and Their Design Equations**	Features of Ideal reactor, Different types of reactors and their design equations: CSTR, PFR; Space Time, Space velocity.	8
4	**Design for Single Reactors**	Size comparison of single reactors, Comparison of CSTR with PFR for first order reaction, CSTR in series: Unequal size, Equal size, PFR in series, PFR in parallel; Reactors of different types in series.	6
5	**Heterogeneous Processes**	Heterogeneous processes: Classification of catalysts, Preparation of catalysts, Promoters and Inhibitors, General mechanism of catalytic reactions surface area	8

		and pore size distribution Rate equation of fluid solid catalytic reactions.	
TOTAL			**40**

4. Readings:

4.1 Textbooks:

1. Y.O. Levenspiel, Chemical reaction engineering, John Wiley and Sons.
2. H. S. Fogler, Essentials of Chemical reaction engineering, Prentice Hall International series.

4.2 Reference Books:

1. L. D. Schmidt, The Engineering of Chemical reactions, Oxford University Press.
2. K. A. Gavhane, Chemical Reaction Engineering-I, Nirali Prakashan.

5. Outcome of the Course:

Students completing the course will be able to:

1) Demonstrate the understanding of basic concepts involved in using reaction rate equations and rate constants.
2) Develop rate laws for homogenous reactions.
3) Design ideal reactors for single reactions.
4) Basic concepts of heterogeneous process, catalyst, inhibitors, promoters etc.

Process Plant Utilities

1.1 Course Number: CE211
1.2 Contact Hours: 3-0-0 Credits:9
1.3 Semester-offered: 2nd Year – Even
1.4 Prerequisite: Diploma level Chemistry, Unit Operations-II and Material Science
1.5 Syllabus Committee Members: Dr. Bhaskar Jyoti Medhi, Dr. Anil Kumar Varma, Dr. Arun Kumar

2. Objective:

i) The objective of this subject is to study the requirement of different utilities and their generation process and utilization for the process plant.
ii) It will also provide platform to study the various properties of insulation materials, inert gases and their specific uses in industries.

3. Course Content:

Unit-wise distribution of content and number of lectures

Unit	Topics	Sub-Topic	Lectures
1	Introduction	Importance of process utilities in chemical industries, Introduction to the use of various utilities.	3
2	Water and Steam	Sources of water, their characteristics, storage and distribution of water, water for boiler use, cooling purposes, drinking and process water treatment reuse and conservation of water, water resources management**.** Steam generation and its application in chemical process plants, distribution and utilization, design of efficient steam heating systems, steam economy, condensate utilization, steam traps, their characteristics, selection and application, waste heat utilization.	8
3	Compressors and vacuum pumps	Types of compressors and vacuum pumps and their performance characteristics. Methods of vacuum development and their limitations, materials handling under vacuum, piping systems, lubrication and oil removal in compressors in pumps.	8
4	Refrigeration systems	Refrigeration system and their characteristics, load calculation and load calculation and humidification and de-humidification equipments, drying and cooling tower, air blending, exhaust, ventilation, cryogenics, their characteristics and production of liquid N_2 and O_2.	8
5	Insulation	Importance of insulation for meeting for the process equipment, insulation material and their effect on various materials of equipment piping, fitting and valves, insulation for high, intermediate, low and sub-zero	6

		temperatures including cryogenic insulation, determination of optimum insulation thickness.	
6	Inert gases	Introduction, properties of inert gases & their use, sources and methods of generation, comparison of nitro generation routes, general arrangement for inerting system, operational, maintenance and safety aspects.	7
Total			**40**

4. Readings:

4.1 Text books:

1. J. Broughton, Process utility systems, Institution of Chem. Engineers U.K.
2. *D. B. Dhone, Plant Utilities,* Nirali Prakashan.

4.2 Reference books:

1. Reid, Prausnitz poling, The properties of gases & liquids, IVth ed. McGraw Hill international.
2. S. C.Arora and, S. Domkumdwar, A course in refrigeration and air conditioning, Dhanpat Rai & Co.(P) ltd.

5. Outcome of the course:

This subject will give the student a thorough knowledge of process utilities such as uses of water, steam generation, working of Compressors and vacuum pumps, uses of refrigeration systems, insulation and inert gases, which is essentially required for working in any chemical or related industry.

Unit Operations Laboratory – II

1.1 Course Number: CE206L
1.2 Contact Hours: 0-0-2 Credits:2
1.3 Semester-offered: 2nd Year –Even
1.4 Prerequisite: Diploma level Mathematics and Physics
1.5 Syllabus Committee Members: Dr. Bhaskar Jyoti Medhi, Dr. Anil Kumar Varma, Dr. Arun Kumar

2. Objective:

This course is designed to introduce a basic study of the phenomena of heat and mass transfer, to develop methodologies for solving a wide variety of practical engineering problems, and to provide useful information concerning the performance and design of particular systems and processes.

3. Course Content:

Sl. No.	Name of the Experiments
1	Study of conduction heat transfer in composite wall
2	Study of conduction heat transfer in metal rod
3	To Find the Logarithmic Mean Temperature Difference (LMTD) effectiveness of Shell and Tube type heat exchanger
4	To study the boiling heat transfer phenomenon
5	To study the evaluation of mass transfer coefficient in wetted wall column
6	Study of the effect of temperature on the diffusion coefficient
7	To study about the mass transfer in case of absorption Packed Column Apparatus
8	To study the drying characteristics of a solid under forced draft condition using Tray Drier
9	To study the characteristics of Batch Distillation

4. Course Outcomes:

After completion of course student will be able to

1) Account for the consequence of heat and mass transfer in analyses of engineering systems
2) Analyze problem and develop confidence in handling the heat and mass transfer equipments used in chemical process industries.
3) Estimation of performance analysis of heat and mass transfer equipments.
4) Develop experimental and technical writing skills.
5) Work in team and develop interpersonal skills.

Chemical Reaction Engineering Laboratory

1.1 Course Number: CE210L
1.2 Contact Hours: 0-0-2 Credits: 2
1.3 Semester-offered: 2nd Year –Even
1.4 Prerequisite: Diploma level Mathematics and Physics
1.5 Syllabus Committee Members: Dr. Bhaskar Jyoti Medhi, Dr. Anil Kumar Varma, Dr. Arun Kumar

2. Objective:

To apply the basics of reaction engineering using different reactors. The course includes experimental execution, data analysis and error analysis, skills development in oral presentation, technical report writing, and team-building.

3. Course Content:

Sl. No.	List of Experiments
1	To study of a Non-Catalytic Homogeneous reaction in an isothermal batch reactor
2	Study of the effect of non-catalytic homogeneous reaction in a series arrangement of PFTR and CSTR
3	To study of a non-catalytic homogeneous reaction in a CSTR
4	Study of the effect of non-catalytic homogeneous reaction in a PFTR
5	To study of a non-catalytic homogeneous reaction in a packed bed reactor

4. Outcome of the Course:

The student will be able to verify the various theoretical principles of reaction engineering using different reactors.