

GUJARAT TECHNOLOGICAL UNIVERSITY
CIVIL & INFRASTRUCTURE ENGINEERING

ADVANCE ENGINEERING MATHEMATICS

SUBJECT CODE: 2130002

B.E. 3rd SEMESTER

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
				Theory Marks			Practical Marks			
				PA (M)		PA (V)				
				PA	ALA	ESE	OEP			
3	2	0	5	70	20	10	30	0	20	150

Content:

Sr. No.	Topics	Teaching Hrs.	Module Weightage
1	Introduction to Some Special Functions: Gamma function, Beta function, Bessel function, Error function and complementary Error function, Heaviside's function, pulse unit height and duration function, Sinusoidal Pulse function, Rectangle function, Gate function, Dirac's Delta function, Signum function, Saw tooth wave function, Triangular wave function, Halfwave rectified sinusoidal function, Full rectified sine wave, Square wave function.	02	4
2	Fourier Series and Fourier integral: Periodic function, Trigonometric series, Fourier series, Functions of any period, Even and odd functions, Half-range Expansion, Forced oscillations, Fourier integral	05	10
3	Ordinary Differential Equations and Applications: First order differential equations: basic concepts, Geometric meaning of $y' = f(x,y)$ Direction fields, Exact differential equations, Integrating factor, Linear differential equations, Bernoulli equations, Modeling , Orthogonal trajectories of curves. Linear differential equations of second and higher order: Homogeneous linear differential equations of second order, Modeling: Free Oscillations, Euler- Cauchy Equations, Wronskian, Non homogeneous equations, Solution by undetermined coefficients, Solution by variation of parameters, Modeling: free Oscillations resonance and Electric circuits, Higher order linear differential equations, Higher order homogeneous with constant coefficient, Higher order non homogeneous equations. Solution by $[1/f(D)] r(x)$ method for finding particular integral.	11	20

4	Series Solution of Differential Equations: Power series method, Theory of power series methods, Frobenius method.	03	6
5	Laplace Transforms and Applications: Definition of the Laplace transform, Inverse Laplace transform, Linearity, Shifting theorem, Transforms of derivatives and integrals Differential equations, Unit step function Second shifting theorem,	09	15
	Dirac's delta function, Differentiation and integration of transforms, Convolution and integral equations, Partial fraction differential equations, Systems of differential equations		
6	Partial Differential Equations and Applications: Formation PDEs, Solution of Partial Differential equations $f(x,y,z,p,q) = 0$, Nonlinear PDEs first order, Some standard forms of nonlinear PDE, Linear PDEs with constant coefficients, Equations reducible to Homogeneous linear form, Classification of second order linear PDEs. Separation of variables use of Fourier series, D'Alembert's solution of the wave equation, Heat equation: Solution by Fourier series and Fourier integral	12	15

Reference Books:

1. Advanced Engineering Mathematics (8th Edition), by E. Kreyszig, Wiley-India (2007).
2. Engineering Mathematics Vol 2, by Baburam, Pearson
3. W. E. Boyce and R. DiPrima, Elementary Differential Equations (8th Edition), John Wiley (2005)
4. R. V. Churchill and J. W. Brown, Fourier series and boundary value problems (7th Edition), McGraw-Hill (2006).
5. T.M. Apostol, Calculus, Volume-2 (2nd Edition), Wiley Eastern, 1980

Course Outcome:

After learning the course the students should be able to

CO1: Define some special functions of mathematics

CO2: Identify differential equations and use various methods to solve them.

CO3: List Laplace and Inverse Laplace Transforms. Use them to solve initial value problems.

CO4: Classify various methods to solve linear and non-linear Partial differential equations and apply them.

CO5: Compare periodic and non-periodic functions. Express these function as Fourier Series and Fourier Integral.

CO6: Explain Regular and Singular Points. Choose appropriate method to find Series Solution.

Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO2130002.1	1	1	-	-	-	-	-	-	1	-	-	1	-	1	-	-
CO2130002.2	3	2	-	-	-	-	-	-	1	-	-	1	-	2	-	-
CO2130002.3	2	2	-	-	-	-	-	-	1	-	-	1	-	1	-	-
CO2130002.4	3	2	-	-	-	-	-	-	1	-	-	1	-	2	-	-
CO2130002.5	2	2	-	-	-	-	-	-	1	-	-	1	-	1	-	-
CO2130002.6	1	1	-	-	-	-	-	-	1	-	-	1	-	1	-	-

GUJARAT TECHNOLOGICAL UNIVERSITY

MECHANICS OF SOLIDS
SUBJECT CODE: 2130003
 B.E. 3RD SEMESTER

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
				Theory Marks			Practical Marks			
			PA (M)		PA (V)					
			PA	ALA	ESE	OEP				
4	0	2	6	70	20	10	20	10	20	150

Sr. No.	Topics	Teaching Hrs.	Module Weightage
Module 1			
1	Introduction Definition of space, time, particle, rigid body, deformable body. Force, types of forces, Characteristics of a force, System of forces, Composition and resolution of forces. Fundamental Principles of mechanics: Principle of transmissibility, Principle of superposition, Law of gravitation, Law of parallelogram of forces.	02	20
2	Fundamentals of Statics Coplanar concurrent and non-concurrent force system: Resultant, Equilibrant, Free body diagrams. Coplanar concurrent forces: Resultant of coplanar concurrent force system by analytical and graphical method, Law of triangle of forces, Law of polygon of forces, Equilibrium conditions for coplanar concurrent forces, Lami's theorem. Application of statically determinate pin – jointed structures. Coplanar non-concurrent forces: Moments & couples, Characteristics of moment and couple, Equivalent couples, Force couple system, Varignon's theorem, Resultant of non-concurrent forces by analytical method, Equilibrium conditions of coplanar non-concurrent force system, Application of these principles.	08	
Module 2			
3	Applications of fundamentals of statics	08	15

	<p>Statically determinate beams: Types of loads, Types of supports, Types of beams; Determination of support reactions, Relationship between loading, shear force & bending moment, Bending moment and shear force diagrams for beams subjected to only three types of loads :i) concentrated loads ii) uniformly distributed loads iii) couples and their combinations; Point of contraflexure, point & magnitude of maximum bending moment, maximum shear force.</p>		
Module 3			
4	<p>Friction Theory of friction, Types of friction, Static and kinetic friction, Cone of friction, Angle of repose, Coefficient of friction, Laws of friction, Application of theory of friction: Friction on inclined plane, ladder friction, wedge friction, belt and rope friction.</p>	06	
5	<p>Centroid and moment of inertia Centroid: Centroid of lines, plane areas and volumes, Examples related to centroid of composite geometry, Pappus – Guldinus first and second theorems. Moment of inertia of planar cross-sections: Derivation of equation of moment of inertia of standard lamina using first principle, Parallel & perpendicular axes theorems, polar moment of inertia, radius of gyration of areas. Examples related to moment of inertia of composite geometry,</p>	08	
Module 4			
6	<p>Simple stresses & strains Basics of stress and strain: 3-D state of stress (Concept only) Normal/axial stresses: Tensile & compressive Stresses :Shear and complementary shear Strains: Linear, shear, lateral, thermal and volumetric. Hooke's law, Elastic Constants: Modulus of elasticity, Poisson's ratio, Modulus of rigidity and bulk modulus and relations between them with derivation. Application of normal stress & strains: Homogeneous and composite bars having uniform & stepped sections subjected to axial loads and thermal loads, analysis of homogeneous prismatic bars under multidirectional stresses.</p>	10	20
Module 5			
7	<p>Stresses in Beams: Flexural stresses – Theory of simple bending, Assumptions, derivation of equation of bending, neutral axis, determination of bending stresses, section modulus of rectangular & circular (solid & hollow), I,T,Angle, channel sections Shear stresses – Derivation of formula, shear stress distribution across various beam sections like rectangular, circular, triangular, I, T, angle sections.</p>	06	
8	<p>Torsion: Derivation of equation of torsion, Assumptions, application of theory of torsion equation to solid & hollow circular shaft, torsional rigidity.</p>	04	

9	Principle stresses: Two dimensional system, stress at a point on a plane, principal stresses and principal planes, Mohr's circle of stress, ellipse of stress and their applications	04	
Module –VI			
10	Physical & Mechanical properties of materials: (laboratory hours) Elastic, homogeneous, isotropic materials; Stress –Strain relationships for ductile and brittle materials, limits of elasticity and proportionality, yield limit, ultimate strength, strain hardening, proof stress, factor of safety, working stress, load factor, Properties related to axial, bending, and torsional & shear loading, Toughness, hardness, Ductility ,Brittleness	05	
11	Simple Machines: (laboratory hours) Basics of Machines, Definitions: Velocity ratio, mechanical advantage, efficiency, reversibility of machines. Law of Machines, Application of law of machine to simple machines such as levers, pulley and pulley blocks, wheel and differential axle, Single purchase, double purchase crab, screw jacks. Relevant problems.	05	

Course Outcome:

After learning the course the students should be able to:

CO1: **Define** fundamental principles of mechanics & principles of equilibrium to simple and practical problems of engineering.

CO2: **Solve** principles of statics to determine reactions & internal forces in statically determinate beams.

CO3: **Discuss** behaviour & properties of engineering materials, basics of simple machines and their working mechanism.

CO4: **Determine** centroid and moment of inertia of a different geometrical shape and able to understand its importance

CO5: **Explain** basics of friction and its importance through simple applications

CO6: **Illustrate** the different types of stresses and strains developed in the member subjected to axial, bending, shear, torsion & thermal loads.

Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO2130003.1	3	2	-	-	-	-	-	-	-	-	-	1	2	-	1	-
CO2130003.2	3	2	-	-	-	-	-	-	-	-	-	-	1	-	-	-
CO2130003.3	3	2	1	-	-	-	-	-	-	-	-	1	1	1	-	-
CO2130003.4	3	1	-	-	-	-	-	-	-	-	-	-	1	-	-	-
CO2130003.5	3	2	-	-	-	-	-	-	-	-	-	1	1	1	-	-
CO2130003.6	3	2	1	1	-	-	-	-	-	-	-	1	2	-	1	-

GUJARAT TECHNOLOGICAL UNIVERSITY

DESIGN ENGINEERING
SUBJECT CODE: 2130005

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks	
				Theory Marks		Practical Marks			
			PA (M)		PA (V)				
				PA	ALA	ESE			
0	0	3	3	0	0	0	80	20	100

Design Engineering 1, 2 and 3

What is design? Design is a plan of a system, its implementation and utilization for attaining a goal. It is to change undesired situation into desired situation means to find solution for undesired/uncomfortable situation.

Designs can be for

- (1) Technical systems (power plant)
- (2) Educational systems (Montessori Method)
- (3) Aesthetic systems (logo designs, advertisements)
- (4) Legal systems
- (5) Social, religious or cultural systems
- (6) Theories, Models, etc.

Design thinking gives students a taste of the rich internal-remunerations associated with knowledge-creation and in curiosity and problem-driven contexts. Design need to satisfy technical functions, ergonomics functions, aesthetic functions, cost function and environment functions.

Essential features of Design:

Design solution of a problem starts with planned constructions for achieving goal/s. Designing means evolving goal oriented processes. At the beginning of the design process only goals are known while at the end, both the goals and plans are known and that to with more clarity. Goal and plans evolve together and they influencing each other. In designing process some goals are more important than others and similarly some plans are better than others. Designing does not guarantee that the design will work.

Design thinking process:

- (1) Find goals or need
- (2) Evaluate goals or need
- (3) Generate proposals to satisfy goals
- (4) Evaluate proposals
- (5) Improve goals and proposals

Teaching methodology:

The design engineering should be with fun and should create excitement. It should be integrated theme across the various courses. It should promote the team work. Design is thinking and doing. The complete design process should be included in design engineering 1, 2 and 3. The prototype design must consider technical, aesthetic, ergonomics, cost and environmental requirements.

Content:

Design Engineering 1: (3 credits in Semester 3, 3 credits in Semester 4)

Introduction to product innovation process (Need-requirement-concept-detail-prototype-services-business)

Modules on: Task clarification and conceptualization: Problem-idea-solution-evaluation

- Problem identification
- Ideation
- Consolidation
- Evaluation

Project: identifying need to developing proof of concept to demonstrate solution selected

Students can tackle simple design problems with engineering content – posed by the teacher or based on a survey of real life concerns of the public. The second is more effective – the students “own the problem” - but has to be accepted by the teacher.

Examples: (a) A device to help carry heavy luggage to the upper floors of a building – a building that has no lifts. (b) Systems to ensure that water does not come out as a jet from the taps in the lower floors of a tall building. One can insist on multiple realistic solutions and all should be part of the submission along with statements of their shortcomings or advantages. Teacher should not entertain fancy solutions – based on fancy ideas - with no engineering or scientific basis.

Short lectures on the topics in the syllabus should parallel the activity.

Design Engineering 2: (3 credits in Semester 5, 3 credits in Semester 6)

Introduction to detail design

Modules on

- Design for performance, safety, reliability
- Design for ergonomics and aesthetics
- Design for manufacturability
- Design for cost, environment

Project: developing the concept into a detailed design with a functional prototype

Here one could ask students to develop products based on themes - “Garbage compactors, Energy from kitchen waste, etc” making sure that the problems identified by the students within the themes possess an engineering content and insisting on some facets of design for assembly, for manufacturability,and so on while preparing the design and the prototypes. One could encourage students to innovate, arrive at multiple solutions and conduct a detailed design of one of the solutions.

Prototyping requires funds and effort, so it pays to identify one subsystem of the design of the whole machine. One can insist on prototyping demonstrating at least that sub-system, if not the whole system.

Course outcomes of 2130001 Design Engineering – I A

After successful completion of the course, student will be able to

- CO2130001.1 Demonstrate the basic concepts of chemical sciences
- CO2130001.2 Define and analyse the problems in chemical engineering
- CO2130001.3 Identify the instrumental techniques used in the chemical engineering
- CO2130001.4 Inculcate the innovative practices in Chemical engineering development

Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO2130001.1	3	-	3	-	1	1	3	1	3	1	-	2	3	1	1	2
CO2130001.2	3	3	3	2	2	2	2	2	3	2	1	2	2	3	1	2
CO2130001.3	3	-	2	2	2	-	-	-	3	-	-	2	2	1	1	1
CO2130001.4	2	1	3	3	1	2	3	2	3	2	2	2	2	2	2	2

Design Engineering 3: (3 credits in Semester 7, 3 credits in Semester 8)

Introduction to services and business planning

Modules on

- Design of services
- Intellectual property
- Materials and recourse planning
- Business planning

Project: developing a business model

OR

Research or Technology Development project

Modules on

- Detailed literature survey and to find out technology gap
- Intellectual property
- Re-evaluate prototype of DE-2 and proposal of novel idea

Project: developing a novel functional prototype

GUJARAT TECHNOLOGICAL UNIVERSITY

CHEMICAL ENGINEERING

ORGANIC CHEMISTRY AND UNIT PROCESSES

SUBJECT CODE: 2130501

B.E. Semester: III

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks					Total Marks	
				Theory Marks			Practical Marks			
				PA (M)		PA (V)				
			PA	ALA	ESE	OEP				
3	0	2	5	70	20	10	20	10	20	150

Content:

Sr. No.	Topics	Teaching Hrs.	Module Weightage
1	General Principles of Organic reactions and Mechanisms: Fission Reaction and reaction intermediates: Free Radical, Carbonium, Carbanion, Carbenes and Nitrenes. Nucleophilles and Electrophilles. Types of Organic reactions and its mechanism: Especially Nucleophilic and Electrophilic Addition and Substitution reactions.	6	60 %
2	Stereochemistry: Optical, Geometrical and Conformational Isomerism: Optical activity, Polarimeter, Specific rotation, Enantiomers, Diastereomers, Optical activity in Lactic and Tartaric acid, R and S configuration of Optically active compound and E and Z designation of Geometrical isomers. Resolution of racemic mixture.	4	
3	Introduction to various Unit Processes and Operations: Nitration, Amination, Hydrogenation, Halogenations, Oxidation, Reduction, Sulphonation, Hydrolysis, Alkylation and Polymerization.	6	
4	Carboxylic acid : Introduction, Preparation and Properties Manufacture Process of Acetic acid, Formic acid, Oxalic acid, Palmitic acid & Stearic acid Derivatives of Carboxylic acids: Acid Amides, Esters, Acid Anhydrides and Acid Chlorides. Mechanism of Esterification and Strengths of Acids.	4	
5	Polynuclear and Heterocyclic Compounds:	4	

	Introduction and Classification. Preparation, Properties and Uses of: Naphthalene, Anthracene, Pyrrole, Furan, Thiophene, Pyridine and Quinoline		
6	Application of following reactions with Mechanism: Diazotisation, Sandmeyer, Cannizzaro, Wolf Kishner, Claisen, Curtius, Baeyer Villiger, Hoffman and Michael Dieckmann reaction.	5	
7	Carbohydrates: Introduction, Classification, Configuration and Chemical reactions of mono, oligo and poly saccharides, especially of Glucose, Fructose and Starch. Conversion of higher to lower and lower to higher aldose (Killiani Synthesis, Ruff & Wohl's Degradation). Conversion of Aldose to Ketose. Manufacturing of Cane Sugar from Sugarcane with flow sheet.	4	
8	Amino acid & Protein Chemistry: Introduction, Composition, Classification & Isolation of Proteins, Qualitative tests of Proteins, Classification of Amino acids & their synthesis. Amphoteric nature, Isoelectric point, Primary, Secondary, Tertiary and Quaternary Structure of Protein, RNA and DNA.	4	
9	Synthetic Drugs: Synthesis of drugs, Antiseptics, Halogenated compounds, Antimalarials, Quinoline derivatives, Antibacterials, Sulpha Aspirin, Phenacetin, Paracetamol, Sulphanilamide, Sulphaguanidine, Chloromycetin, Chloroquine.	6	
10	Colour, Dyes and Pigments: Introduction, Classification of dyes based on Application and Structural representation. Colour and Constitution Theory: Quinonoid, Valence bond and Molecular Orbital theory Application of Dyes and Pigments. Preparation of some imp derivatives: Congo red, Malachite Green, Crystal Violet, Alizarin, Phenolphthalein, Fluorescein, Eosin and Indigo .	5	
11	Petroleum Chemistry: Occurrence- Composition of Crude oil- Distillation of the Crude oil, Cracking, Knocking, Octane number & Cetane number, Synthetic petrol.	6	

Reference Books:

Sr. No.	Title/Author/Publisher
1.	A Text Book Of Organic Chemistry by P. L. Soni, Sultan Chand & Sons, New Delhi.
2.	A Text Book of Organic Chemistry by Arun Bahl and B.S. Bahl, Sultan Chand & Sons, New Delhi
3.	A Textbook of Organic Chemistry by Raj K Bansal, New Age International, New Delhi
4.	Organic Chemistry By Solomons, John Willey & Sons, USA.
5.	Organic Chemistry, I. L. Finar Vol. I & II ELBS & Longmans, Green – UK
6.	Organic Chemistry

	By Morrison and Boyd, Pearson Education, Singapore.
7.	A Textbook of Organic Chemistry By Francis A Carey, Springer –USA
8.	Organic Reaction and their Mechanisms By P S Kalsi, New Age International, New Delhi
9.	Atomic Structure and the Chemical Bond By Manas Chanda, Tata Mcgrawhill
10.	Heterocyclic Chemistry By Bansal B K, New Age International, New Delhi
11.	Organic Chemistry By R L Madan, S. Chand & Company, New Delhi
12.	Laboratory Techniques in Organic Chemistry By Ahluwalia V K, I K International, New Delhi
13.	Unit Process in Organic Synthesis By P H Groggins, Tata Mc Graw Hill, New Delhi.
14.	Vogel's textbook of Qualitative Organic Analysis, By Arthur I Vogel, Revised by Jefferey et al. Publisher: Addison Wessley Longmann Ltd, England

Course Outcome:

After learning the course the students should be able:

CO1: **Relate** organic chemistry with chemical industries

CO2: **Interpret** the reactivity of an organic compound from its structure

CO3: **Apply** the basic practical skills for the synthesis and analysis of organic compounds.

CO4: **Justify** the reasonable mechanisms and methods for an organic synthesis.

Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO2130501.2	1	2	-	1	-	-	-	-	-	-	-	-	-	2	1	-
CO2130501.1	2	1	-	-	-	2	-	-	-	-	-	1	-	-	-	-
CO2130501.3	1	-	-	2	1	-	-	-	2	1	1	-	1	1	-	1
CO2130501.4	2	-	-	2	1	-	-	1	-	-	-	-	1	-	1	-

GUJARAT TECHNOLOGICAL UNIVERSITY
CHEMICAL ENGINEERING

FLUID FLOW OPERATION

SUBJECT CODE: 2130502

B.E. Semester: III

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
				Theory Marks			Practical Marks			
			PA (M)		PA (V)					
			PA	ALA	ESE	OEP				
3	0	2	5	70	20	10	20	10	20	150

Content:

Sr. No.	Topic	Teaching Hours	Module Weightage (%)
1.	Fluid static and its application: Nature of fluids, Pressure concept, Hydrostatic equilibrium, decanters like continuous gravity, centrifugal etc.	02	
2.	Fluid Flow Phenomena: Velocity fluid, Velocity gradient and rate of shear, Newtonian and Non-Newtonian fluids, Viscosity and momentum flux, Reynolds number and its significance, laminar and turbulent flow; Turbulence, Reynolds stresses, Eddy viscosity, Laminar and Turbulent flow in boundary layers, boundary layer formation in straight tubes, boundary separation and wake formation.	05	
3.	Basic equations of Fluid Flow: Mass velocity; average velocity; potential flow; streamlines, stream tubes, macroscopic momentum balance, momentum correction factor, Equation of continuity, Bernoulli's equation, corrections for fluid friction, pump work in Bernoulli's equations, angular momentum equations	05	
4.	Flow of incompressible fluids in Conduits and Thin Layers: Flow of incompressible fluids in Conduits and Thin Layers in pipes, relation between skin friction and wall shear, friction factor laminar flow in pipes, kinetic energy correction factor and momentum correction factor for laminar flow of Newtonian fluids, Hagen-Poiseuille equation, effect of roughness, friction factor chart, friction factor inflow through channels of non-circular cross section, equivalent diameter, hydraulic radius, friction from changes in velocity or direction, flow through sudden enlargement of cross section, flow through sudden contraction of cross section, effect of fittings and valves, form friction losses in	07	

	Bernoulli's equations, separation of boundary layers in diverging channel.		
5.	Flow of Compressible fluids: Mach number, continuity equation total energy balance equation, velocity of sound, processes of compressible of flow like isentropic expansion, adiabatic frictional flow, isothermal frictional flow, velocity in nozzles.	04	
6.	Flow past immersed bodies: Introduction to Drag, drag coefficient, form drag, and stream lining, friction in fluids through bed of solids, fluidization, condition of fluidization, types of fluidization, application of fluidization, continuous fluidization, slurry and pneumatic transport.	04	
7.	Transportation and Metering of fluid: Pipe and tubing, joint and fittings selection of pipe sizes, prevention of leakage around moving parts, stuffing boxes, mechanical seals, valves like Gate, Globe, Plug cocks, Ball, Check valves.	06	
8.	Fluid moving machinery: Pumps its characteristics like developed head power requirement suction lift and cavitations; positive displacement pumps like reciprocating, rotary pumps, centrifugal pumps and its theory, characteristic of head capacity relation, pump priming, fans, blowers like positive displacement, centrifugal blowers, compressor efficiency, vacuum pumps, jet ejectors, comparison of devices for moving fluids.	08	
9.	Measurement of flowing fluids: Full bore meter like venturimeter, orifice meter, coefficient of discharge of venturimeter, orifice meter, area meters like Rotameter, target meters, vortex-shedding meters, coriolis meters, magnetic meters etc., insertion meters like pitot tubes etc. Recent advancement in different pumps, valves and measuring devices.	08	
10.	Dimensional Analysis: Different methods of dimensional analysis applied to fluid flow problems.	05	

Reference Books:

- "Unit Operations of Chemical Engineering", McCabe W L, Smith J C, Harriott P, Mc Graw Hill Publication, 7th edition 2005.
- "Chemical Engineering" Vol. I – Fluid flow, Heat Transfer and Mass Transfer; Coulson & Richardson's, Butterworth – Heinemann Publication, 6th Edition.
- "Fluid Dynamics and Heat Transfer", James G. Knudson and Donald L. Katz, Mc Graw Hill Publication

Course Outcome:

After learning the course the students should be able:

- CO1: **Understand** the various physical properties and flow regimes of fluids
CO2: **Apply** the basic equations to solve fluid flow problems
CO3: **Analyze** the phenomena involving flow through pipes
CO4: **Select** appropriate fluid transport and metering devices
CO5: **Evaluate** the performance of fluid transport and metering devices

Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO2130502.1	3	1	-	-	-	-	-	-	-	-	-	-	2	1	-	-
CO2130502.2	2	3	-	-	-	-	-	-	2	-	-	1	2	2	1	-
CO2130502.3	2	3	-	-	2	-	-	-	2	1	-	2	2	2	1	-
CO2130502.4	2	2	2	-	1	-	-	-	1	1	-	2	2	-	1	1
CO2130502.5	2	2	2	-	1	-	-	-	2	1	-	2	2	2	-	1

GUJARAT TECHNOLOGICAL UNIVERSITY
CHEMICAL ENGINEERING

PROCESS CALCULATION
SUBJECT CODE: 2130504
B.E. Semester: III

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks					Total Marks	
				Theory Marks			Practical Marks			
				PA (M)		PA (V)				
			PA	ALA	ESE	OEP				
3	1	0	4	70	20	10	30	0	20	150

Course Contents:

Sr. No.	Topic	Teaching Hrs.	Module Weightage
1	Dimensions and units: Dimensions and system of units, Fundamental and derived units, Dimensional consistency, Dimensional equations, Different ways of expressing units of quantities and physical constant, Unit conversion and its significance	5	9
2	Basic chemical calculations: Calculations for mole, molecular weight, equivalent weight, etc., Composition of gaseous mixtures, liquid mixtures, solid mixtures, etc., Ideal gas law & other equations of state and their applications, Dalton law, Raoult's law, Henry's law, Solutions and their properties	7	13
3	Material balance without chemical reactions: Process flowsheet, Degree of freedom, Material balance with and without recycle; Bypass and purge streams, Material balance around equipments related to unit operations like absorber and stripper, distillation towers, extractors, dryers, evaporators, etc. Material balance of unsteady state operations.	8	15
4	Material balance involving chemical reactions: Concept of limiting and excess reactants, percentage conversion, yield, selectivity, etc., Material balance with chemical reactions - single and multiple reactions, Material balance involving reactions with special reference to fertilizers, petrochemicals, dyestuffs, electrochemical industries, metallurgical industries, etc.	10	18
5	Energy balances: Thermochemistry and 1 st law of thermodynamics, Heat capacity of gases	9	17

	and gaseous mixtures, liquids & solids, Sensible heat change in liquids & gases, Enthalpy changes during phase transformation, Enthalpy changes accompanied by chemical reactions, Standard heat of reaction, Adiabatic reactions, Thermo-chemistry of mixing processes, Dissolution of solids, etc.		
6	Stoichiometry and Unit operations: Distillation, Absorption and stripping, Extraction & leaching, Crystallization, Psychrometric Operations, Drying, Evaporation etc.	7	13
7	Fuels and combustion: Types of fuels, Calorific value of fuels, Problems on combustion of coal, liquid fuels, gaseous fuels, etc., Proximate and ultimate analysis, Combustion calculations, theoretical flame temperature, etc., Air requirement and flue gases.	8	15

Reference Books:

1. "Stoichiometry", B.I. Bhatt, S.M. Vora, McGraw Hill Publishing Company Limited, 4th edition, 2004.
2. "Basic Principles & Calculations in Chemical Engineering", David M. Himmelblau, James B. Riggs, PHI Learning Pvt. Ltd, 7th edition, 2006.
3. "Elementary Principles of Chemical Processes", Richard M. Felder, Ronald W. Rousseau, Wiley, 3rd edition, 2004.
4. "Chemical Process Principles Part-I: Material and Energy Balances", O.A.Hougen, K.M.Watson, R.A.Ragatz, CBS Publishers New Delhi, 2nd edition, 2004.
5. "Stoichiometry and Process Calculations", K.V. Narayanan, B. Lakshminikutty, Prentice-Hall of India Pvt. Ltd., 2006.
6. "Industrial Stoichiometry: Chemical Calculations of Manufacturing Processes", H.C.Lewis, W.K.Lewis, A.H.Radasch, McGraw-Hill, 2nd edition, 1954.

Course Outcome:

After learning the course, the students should be able to:

CO1: **Understand** the units, dimensions and basic chemical engineering principles

CO2: **Apply** the principles of material balance for chemical plant having different unit operations and unit processes

CO3: **Formulate** and solve energy balance including thermal properties estimation for unit operations and unit processes of chemical industries

CO4: **Appreciate** the concept of fuels & combustion to solve material & energy balance of unit operation & unit process of chemical engineering

Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO2130504.1	3	-	-	-	-	-	-	-	-	-	-	3	2	-	-	-
CO2130504.2	3	3	1	1	-	-	-	-	2	1	-	3	2	-	-	1
CO2130504.3	3	3	1	1	-	-	1	-	2	2	-	2	2	-	-	1
CO2130504.4	3	3	1	1	-	-	1	-	1	-	-	2	2	-	1	1

GUJARAT TECHNOLOGICAL UNIVERSITY

CHEMICAL ENGINEERING CHEMICAL PROCESS INDUSTRIES - I

SUBJECT CODE: 2130505

B.E. Semester: III

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
				Theory Marks			Practical Marks			
			PA (M)		PA (V)					
			PA	ALA	ESE	OEP				
3	0	2	5	70	20	10	20	10	20	150

Content:

Sr. No.	Topic	Teaching Hours	Module Weightage (%)
1.	Chemical processing and the work of chemical engineering: Basic chemical data, batch and continuous processing, flowcharts etc.	02	20
2.	Water : Water treatment for industrial and domestic use such as demineralization, deionization, desalination, reverse osmosis, etc...	06	
3.	Sulfur and Sulfuric acid: Mining of sulfur, Manufacture of sulfuric acid by DCDA process and its applications. Manufacturing technologies, Engineering problems, Energy recovery from the process. Introduction to Fertilizer industries, manufacturing processes of Ammonia, Urea, Nitric acid, Phosphoric acid their uses and applications, major engineering problems, NPK fertilizer.	08	
4.	Chlor-alkali and Heavy Inorganic industry: Manufacturing of caustic soda and chlorine by membrane cell process, Manufacturing of Sodium bicarbonate.	06	
5.	Introduction to industrial gases and carbon: Gases like carbon dioxide, oxygen, nitrogen, hydrogen, rare gases of atmosphere, helium, acetylene, sulfur dioxide, carbon monoxide, nitrogen oxide. Carbon like carbon black, activated carbon, natural graphite, Manufacturing of graphite and carbon, industrial diamonds.	08	
6.	Introduction to ceramic industries. Portland cements, calcium and magnesium compounds, glass industries.	08	
7.	Introduction to explosives, propellants and toxic chemical agents, photographic products industries.	08	
8.	Introduction to pulp and paper industries: Kraft process, Paper making process ,etc..	08	

Reference Books:

1. "Shreve's Chemical Process Industries", George T. Austin, McGraw Hill Publication, 5th edition
2. "DRYDENS outlines of chemical technology for the 21st century", M Gopalarao & Marshal Sitting, pub East-West Press, 3rd edition
3. "General chemical technology", Shukla and Pandey.

Course Outcome:

After learning the course the students should be able:

CO1: **Understand** the manufacturing processes of various chemicals and products.

CO2: **Identify** major engineering problems encountered in manufacturing processes

CO3: **Compare** and contrast various process of manufacturing

CO4: **Comprehend** the process flow diagrams for various chemicals and products

CO5: **Appreciate** the modern techniques & recent development for manufacturing of various chemicals and products

Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO2130505 .1	3	1	-	-	-	-	-	-	1	1	-	-	3	1	2	1
CO2130505 .2	3	1	-	-	-	2	2	-	-	-	-	-	3	-	2	-
CO2130505 .3	3	-	-	-	-	-	1	-	1	-	-	2	2	-	1	-
CO2130505 .4	3	-	-	-	-	2	2	-	-	-	-	-	1	-	-	1
CO2130505 .5	3	1	2	-	-	-	-	-	-	-	-	2	2	-	1	1

GUJARAT TECHNOLOGICAL UNIVERSITY

CHEMICAL ENGINEERING (05)

MASS TRANSFER OPERATION-I

SUBJECT CODE:2150501

B.E. 5th SEMESTER

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
				Theory Marks			Practical Marks			
				PA (M)		ESE (V)				
				PA	ALA	ESE	OEP			
3	0	3	6	70	20	10	20	10	20	150

Content:

Sr. No.	Content	Total Hrs	% Weightage
1	Introduction: Classification of mass transfer operation, choice of separation method, Methods of conducting mass transfer operations, Design principles	04	07
2	Molecular Diffusion in Fluids: Definition of molecular and eddy diffusion, Ficks first law, Concept of N & J Flux, Steady state molecular diffusion in fluids at rest and in laminar flow, concept of effective diffusivity. Diffusivity of gases, Diffusivity of liquids.	10	18
3	Mass Transfer Coefficients: Mass transfer in laminar and turbulent regions, F and k type mass transfer coefficients, Film, Penetration and surface renewal theories.	04	08
4	Inter Phase Mass Transfer: Concept of equilibrium, diffusion between phases, Two resistance theory, Local overall mass transfer coefficient, controlling mass transfer resistances.	04	08
5	Gas Absorption: Equilibrium Solubility of gases in liquids, Ideal and non-ideal solution, Choice of solvent for absorption, Material balance and liquid-gas ratio for absorption and stripping, Counter current multi stage operation (isothermal), Absorption factor, Continuous contact equipments, Overall coefficient and Transfer units, Concept of HETP and HTU, NTU and j_H factor, Industrial absorbers. Dilute solutions, Absorption with chemical reaction	08	15

6	Equipments for Gas Liquid Operations: Gas Dispersed: Sparged vessels, Mechanically agitated vessels, Gas-Liquid contact, Tray Tower, Tray tower internals, Different types of trays, Weirs, Downcomers and criteria of their selection, Flooding, Loading, Coning, Weeping & dumping in tray tower; Liquid Dispersed: Ventury scrubber, Wetted wall towers, spray towers, Packed Towers, Packedtowerinternals,Differenttypesofpackingsandtheirselection criteria, mass transfer coefficient for packed towers, Co-current flow of gas & liquid, End effects and axial mixing, Tray tower vs. Packed tower.	08	15
7	Liquid-Liquid Extraction: Ternary liquid- liquid equilibrium and tie line data, system of three liquids-one pair partially soluble, system of two partially soluble liquids-one solid, multi-component system, stage wise contact, Single stage & multistage extraction, Co-current and cross current extraction, Continuous counter current multistage extraction with and without reflux, Theory & performance of continuous contactequipments, Single stage & multistage equipments, Applications of liquid-liquid extraction.	07	13
8	Leaching: Steady state and unsteady state leaching operations, Single stage leaching, Multistage cross current and counter current leaching, Rate of leaching,Recoveryofsolventvapors,Applicationofleaching,Leaching equipments	04	08
9	Crystallization: Saturation, Nucleation, Principle of crystallization, Crystallization rate, Equilibria and yields, Nucleation, Crystal growth, Caking of crystals, Application of crystallization, Crystallization equipments, Crystallization from melts	05	08

Reference Books:

1. "Masstransferoperation" byR.E.Treybal,Mc-GrawHillinternational, 3rdedition
2. "MassTransfer"bySherwood,Pigford&Wilke,Mc-GrawHillinternational.
3. "ChemicalEngineering",Volume-2,byCoulson&Richardson,4thedition
4. Perry'sChemicalEngineers handbook,byPerry&Green,Mc-Graw.Hill international, 7thedition
5. UnitOperationsofChemicalEngg.ByW.L.McCabe,J.C.Smith&Harriott,Mc-GrawHillinternational, 6thedition

Course Outcome:

After learning the course the students should be able to:

CO1: **Understand** the fundamentals and various mechanisms of mass transfer & mass transfer operations like diffusion, gas absorption, extraction, leaching & crystallization.

CO2: **Estimate** the diffusivity for the molecular diffusion in gases and liquids

CO3: **Develop** the concept of local and overall mass transfer coefficients for interphase mass transfer

CO4: **Evaluate** the performance of various mass transfer operations like diffusion, gas absorption, extraction and leaching.

Course Outcome	P01	P02	P03	P04	P05	P06	P07	P08	P09	P010	P011	P012	PS01	PS02	PS03	PS04
CO2150501.1	3	-	-	-	-	-	-	-	1	2	-	1	3	-	-	1
CO2150501.2	2	2	1	-	-	-	1	-	2	1	-	1	2	-	-	1
CO2150501.3	2	1	-	-	-	-	-	-	2	1	-	-	1	-	-	1
CO2150501.4	3	3	2	1	-	2	1	-	2	2	-	2	3	2	2	1
CO2150501	3	3	2	1	-	2	1	-	2	2	-	2	3	2	2	1

GUJARAT TECHNOLOGICAL UNIVERSITY

CHEMICAL ENGINEERING (05)

MECHANICAL OPERATION

SUBJECT CODE: 2150502

B.E. 5th SEMESTER

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
				Theory Marks			Practical Marks			
			PA (M)		ESE (V)					
			PA	ALA	ESE	OEP				
4	0	3	7	70	20	10	20	10	20	150

Content:

Sr. No.	Content	Total Hrs	% Weightage
1	Solids and Its Flow Properties: Characterization of solid particles, Mixed particles sizes and analysis, Screen analysis, properties of particulate masses, Mixing of solids, Mixer for cohesive solids, Mixer for free flowing solids.	08	15
2	Size Reduction, Enlargement, Screening: Principles of comminution, Rittinger's and kick's laws, Bond's crushing law and work index, Size reduction equipments, crushers, grinders, Ultra finegrinders, Cutting machines, Opencircuit and closed circuit operation, Screening equipment, Comparison of ideal and actual screens, Screen effectiveness.	12	22
3	Fluidization and Conveying: Conditions for Fluidization, Types of fluidization, Applications of fluidization, Slurry and pneumatic transport, Conveyers.	10	19
4	Filtration and Sedimentation : Introduction, Cake filters, Filter press, Shell and leaf filters, Discontinuous vacuum filters, Continuous vacuum filters, Centrifugal filters, Filter media, Filter aids, Principles of cake filtration, Clarifying filters, Gravity classifiers, Sink and float method, Differential settling methods, Clarifiers and thickeners, Batch sedimentation, Rate of sedimentation, Thickeners, sedimentation zones in continuous thickeners, Cyclones, Hydrocyclones, Centrifuges.	15	28

5	Mixing and Agitation: Different types of agitators and their selection criteria, Calculation of power required for agitation, Scale up of agitated vessel, Static mixers.	09	16
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Reference Books:

1. Foust A. S. & associates, "Principles of Unit Operations" John Wiley and Sons(1980).
2. McCabe Smith, "Unit Operation in Chemical Engineering" 5th ed. McGraw Hill(1985).
3. Perry R.H. & Chilton C.H., "Chemical Engineers Hand Book", 7th ed. McGrawhill.
4. Badger and Bencharo, "Introduction to Chemical Engineering". Tata McGrawhill.
5. S. K. Gupta, "Momentum Transfer Operation". Tata McGraw Hill(1979)
6. Davidson J.F. & Harrison D."Fluidization" Academic press(1985)
7. Kunni & Levenspiel "Fluidization engineering "Wiley (1962) 8. Brown, G.G. and associates "Unit operations" Wiley, New York,(1950).
8. Coulson and Richardson: Chemical Engineering, Vol. 2.Butterworth HeinemannPub
9. Welty, Wicks, Wilson & Rorrer, Fundamentals of Momentum, Heat and Mass Transfer, 4th ed. Wiley Narayanan C.M.& Bhattacharya B.C. "Mechanical Operations for Chemical engineers", Khanna Publishers. 3 rdEd.1999

Course Outcome:

After successful completion of the course, student will be able to

CO1: **Relate** theoretical and practical concept of mechanical operations used in chemical industry.

CO2: **Understand** the concept of size reduction , solid- solid separation, solid-fluid separation, agitation, mixing & conveying equipments.

CO3: **Appreciate** the applications of various mechanical separations like filtration, sedimentation, centrifugal separations, fluidization.

CO4: **Select** suitable type of size reduction,filtration, screening,agitation, mixing & conveying equipments.

CO5: **Evaluate** the performance of size reduction ,mixing & size separation equipments.

Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO2150502.1	3	-	-	-	-	-	-	-	-	-	-	2	3	-	2	-
CO2150502.2	3	2	-	-	-	-	-	-	1	1	-	1	3	-	1	1
CO2150502.3	3	1	-	-	-	-	-	-	1	1	-	1	1	1	-	1
CO2150502.4	3	2	-	-	-	-	-	-	-	-	3	1	3	-	2	-
CO2150502.5	3	3	-	-	-	-	-	-	1	1	3	1	1	2	-	1

GUJARAT TECHNOLOGICAL UNIVERSITY
CHEMICAL ENGINEERING (05)
MASS TRANSFER OPERATION-II
SUBJECT CODE: 2160501
B.E. 6th SEMESTER

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
L	T	P		Theory Marks			Practical Marks			
			ESE (E)	PA (M)		ESE (V)		PA (I)		
PA	ALA	ESE		OEP						
3	0	3	6	70	20	10	20	10	20	150

Content:

Sr. No.	Content	Total Hrs	% Weightage
1	Distillation: Introduction, Vapor-liquid Equilibria, P - x - y T - x - y diagrams, concept of relative volatility and effect of P and T on equilibrium data, Ideal solutions, Raoult's Law as applied to distillation operations, Deviation from ideality, Minimum and maximum boiling azeotropic mixtures, Enthalpy-concentration diagrams. Flash distillation, steam distillation, simple distillation, continuous rectification, Binary systems, Batch fractionation etc., Determination of number of stages by Ponchon and Severit method and McCabe-Thiele method, Concept of minimum, total and optimum reflux ratio, Reboilers, Use of open steam, , Partial condensers, cold hot circulating reflux etc. Azeotropic Distillation, Extractive Distillation, Concept of Multicomponent distillation.	22	41
2	Humidification Operations: VLE and Enthalpy for pure substances, Saturated and unsaturated vapour-gas mixtures and related terminologies such as dry bulb temperature, dew point, wet bulb temperature, percentage & relative saturation, adiabatic saturation temperature, humid heat, humid volume etc. Psychrometric chart & Psychrometric relation for air-water system, adiabatic saturation curves, wet bulb temperature theory, Lewis relation, Adiabatic operation, cooling towers.	11	21
3	Adsorption and Ion exchange: Adsorption, Definition and industrial application, Types of adsorption, nature of commonly used adsorbents, Adsorption Equilibria, Single gases and vapors, Adsorption hysteresis, Effect of temperature on adsorption, Heat of adsorption, Adsorption of solute from dilute liquid solution, Adsorption from concentrated solutions, Material balance and Freundlich's equation for single	11	20

	stage operation and multistage cross-current operation, counter current operation, Equipments for adsorption such as fluidized bed & Teeter beds, Moving bed & fixed bed unsteady state adsorbers, concept of adsorption wave. Ion-Exchange Principles, Applications, Equilibria and Rate of ion exchange		
4	Drying: Equilibrium relationship & hysteresis, various types of moisture in drying, Batch drying, rate of drying, time of drying, Cross-circulation drying, concept of <i>NoG</i> and <i>HoG</i> , Drying at low temperature, Freeze drying etc. Batch & continuous drying equipments-Tray dryer, Tunnel dryer, Rotary dryers, Spray dryers, Fluidized bed dryer, etc.	10	18

Reference Books:

1. "Mass transfer operation" by R. E. Treybal, Mc-Graw Hill international, 3rd edition
2. "Mass Transfer" by Sherwood, Pigford & Wilke, Mc-Graw Hill international.
3. "Chemical Engineering", Volume-2, by Coulson & Richardson, 4th edition
4. Perry's Chemical Engineers hand book, by Perry & Green, Mc-Graw.Hill international, 7th edition
5. Unit Operations of Chemical Engg. By W. L. Mc Cabe, J.C .Smith & Harriott, Mc-Graw Hill international, 6th edition

Course Outcome:

After learning the course the students should be able to

1. understand the fundamentals of mass transfer operations like distillation, drying, humidification , adsorption and ion exchange
2. analyse industrial problem and apply concepts of mass transfer operations
3. calculate number of theoretical stages and optimum operating conditions for various mass transfer operations
4. select equipment for mass transfer operations like distillation, drying, humidification, adsorption and ion exchange
5. evaluate the performance of mass transfer operations like distillation, drying, humidification, adsorption and ion exchange

Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO2160501.1	3	1	-	-	-	1	-	-	1	-	-	1	3	-	-	-
CO2160501.2	3	3	-	-	-	-	-	-	2	1	-	1	2	2	-	-
CO2160501.3	3	3	2	1	1	-	-	-	2	2	-	1	2	2	-	1
CO2160501.4	2	1	2	-	-	-	1	-	-	-	-	1	2	3	-	-
CO2160501.5	2	2	1	1	-	-	1	-	1	1	-	1	2	1	-	1
CO2160501	3	3	2	1	1	1	1	-	2	2	-	1	3	3	-	1

GUJARAT TECHNOLOGICAL UNIVERSITY
CHEMICAL ENGINEERING (05)
PROCESS EQUIPMENT DESIGN-I
SUBJECT CODE: 2160503
B.E. 6th SEMESTER

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks					Total Marks	
				Theory Marks		Practical Marks				
						PA (M)		ESE (V)		
						PA	ALA	ESE	OEP	
4	0	3	7	70	20	10	20	10	20	150

Content:

Sr. No.	Content	Total Hrs	% Weightage
1	Process design of piping, Fluid moving devices and Flow meters: Introduction, Process design of piping, $NPSH_A$ & $NPSH_R$, Power required by pump, evaluation of Centrifugal pump performance when handling viscous liquids, Power required in Fan, Blower and adiabatic compressor, flow meters, Process design of Orifice meter, Rotameter etc	10	14
2	Process design of Heat exchangers: Shell & Tube heat exchangers, Functions of various parts of shell & Tube Heat exchanger, General design method of shell & tube heat exchanger, Criteria of selection among Fixed Tube sheet, U Tube & Floating Head heat exchanger, Process design of without phase change heat exchanger, Process design of condenser, Criteria of selection for Horizontal and vertical condenser, Process design of Kettle type & Thermosyphon Reboilers and vaporizers, Tinker's flow model, Air cooled heat exchangers and air heaters, plate heat exchangers, etc.	20	27
3	Process design of Distillation Column: Introduction, Criteria of selection, Selection of equipment for distillation, Distillation column design, Selection of key components for multi-component distillation, Determination of operating pressure for distillation column, Advantages & disadvantages of vacuum distillation, Determination of nos. of theoretical stages for binary distillation by McCabe Thiele method Determination of nos. of theoretical stages for multi-component distillation by Fenske- Underwood-Gilliland's method, Selection of trays, Calculations for tower diameter & pressure drop of sieve tray tower, Checking of conditions for weeping, down comer flooding, liquid entrainment, etc, tray efficiency, Jet Flooding & down comer Flooding, Different types of weirs & down comers of tray tower, their selection criteria,	18	25
4	Process design of Absorbers: Introduction, Criteria for selection among different types of absorption equipment, Process Design of packed tower type absorber: Determination of actual amount of solvent, Selection of packing, Determination of tower diameter & pressure drop, Determination of N_{toG} , H_{toG} & height of packing, Process design & selection criteria of liquid distributors, redistributors & packing support, Process design of Spray chamber or spray tower type absorber, Venturi Scrubber.	12	17

5	Process design of Extractor: Industrial applications of liquid-liquid extraction, choice of solvent, Process design of counter current multistage extractor, Selection criteria among different types of extractor, Process design of mixer-settler type extractor & packed tower type extractor, Guidelines for the design of other types of extractors	12	17
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Reference Books:

1. Ray Sinnott, Gavin Towler, Chemical Engineering Design - Principles, Practice and Economics of Plant and Process Design, Butterworth - Heinemann, 2008.
2. Introduction to Process Engineering and Design by S B Thakore and B I Bhatt, Tata McGraw Hill, 1st Edition, 2007.
3. Brownell and Young, Process Vessel Design, Wiley Eastern, 1977.
4. M. S. Peters and K. D. Timmerhaus, Plant Design and Economics for Chemical Engineers, 4th ed., McGraw - Hill, New York, 1991.
5. Ludwig, E. E., Applied process design for chemical and petrochemical plants , volume 1,2 & 3, Third Edition, Butterworth- Heinemann, 1997
6. TEMA Standards.
7. Don W. Green, Robert H. Perry, Perry's Chemical Engineers' Handbook, 8th Edn., McGraw -Hill, New York, 2008
8. James R. Couper, James R. Fair & W. Roy Penney, Chemical Process Equipment - Selection and Design, 2ndEdn., Butterworth - Heinemann, 2010.

Course Outcomes:

After successful completion of the course, student will be able to

1. understand the design parameters for process design of piping, fluid moving equipments and flow meters
2. understand and apply design parameters for equipments used in process plant
3. select suitable type of equipment for various unit operations
4. design the major equipments of process plant

Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO2160503.1	3	2	2	2	-	-	1	-	2	2	-	2	3	2	-	1
CO2160503.2	2	3	2	1	-	-	-	-	1	1	-	2	3	2	-	1
CO2160503.3	3	1	2	-	-	1	1	-	2	1	-	2	3	2	2	-
CO2160503.4	3	3	3	2	1	1	1	1	2	1	-	2	3	3	1	1

GUJARAT TECHNOLOGICAL UNIVERSITY
Chemical Engineering POLLUTION CONTROL & SAFETY
MANAGEMENT
SUBJECT CODE: 2160504
B.E. 6th SEMESTER

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
L	T	P		Theory Marks			Practical Marks			
			ESE (E)	PA (M)	ALA	ESE (V)	OEP	PA (I)		
3	0	0	3	70	20	10	0	0	0	100

Content:

Sr. No.	Content	Total Hrs	% Weightage
A.	Pollution Control		
1	Environmental Protection: Concept of environment and ecology, various natural cycles in environment and ecology, effect of human activities on environment and ecology. Various types of environmental pollution in general and in chemical and allied industry in particular, sources and causes of environmental pollution, effect of pollution on environment, environmental impact assessment and Environment Impact Statement, methodologies for environmental pollution prevention (including process technology up gradation, development, Invention etc.), control, abatement and treatment and waste disposal. Rules, regulations, laws etc. regarding environmental protection, pollution prevention and control, waste disposal etc. Role of government, semi/quasi govt. and voluntary organizations. Current trends and topics	18	33
2	Industrial Laws and Act: Introduction to Industrial laws, Industries Factory act, Energy audit, Environment Audit, Trade union, Labour laws and acts. Industrial Electricity rules, Industrial Dispute Acts, Workmen compensation Act, ESIC Act, Payment and Wages act, Minimum Wages act, Payment of Bonus act, Recent trends and practices in Safe industrial practices	08	15
B.	Safety Management:		
1.	Safety Management: Development of safety movement, Need for safety 1. General Introduction Historical Background and Growth of Safety Science, Aims of Safety Science, Safety and the Organization, safety audit 2. Basic Concepts of Safety Science. Hazard, Risk, Nature of the accident process, Use of Engineering 3. Risk Assessment & Hazard Identification Checklist procedure, Preliminary hazard analysis, What if analysis, Failure mode effect analysis, Hazard and operability (HAZOP) studies, Hazard	10	19

	analysis techniques: Fault tree analysis, Event tree analysis, General outline of DOW index, Risk estimation and management, Major hazard control		
2.	4. Fault and Event Tree Analysis for Risk Prediction 5. Source Models Models of Accidental Release of Toxic/Flammable liquids and vapors, Models of flow of liquids and vapors through pipes. 6. Dispersion Models: Mathematical Models for prediction of Dispersion patterns for toxic/flammable materials released into atmosphere, various types of "plume" and "puff" models of dispersion. 7. Nature of fires and explosion Calculation of Blast damage due to over-pressure, prevention of fires and explosions. 8. Control of Major Chemical Hazards, Emergency Control and disaster planning, On-site and Off-site emergency preparedness. 9. Introduction to various personal protective equipments 10. Instruments for safety : Pressure safety valve, Rupture disc , Interlocks etc.	18	33

Reference Books:

1. Frank P Lees, "Loss Prevention in Process Industries" Volume 1, 2 & 3
2. Industrial Organization and Economics by T.R. Banga & S.C. Sharma
3. "Chemical Process Safety, Fundamentals with Applications", Second Edition by Daniel A. Crowl & Joseph F. Louvar Published by Prentice Hall, Inc. ISBN 0-13-018176-5
4. Environment Engineering by Metcalf and Eddy.
5. Environmental Pollution Control Engineering By C.S.Rao.
6. Environmental Science by Dr. Y.K. Singh, New international publishers.
7. Environmental Engineering and Management by Dr. Suresh K. Dhameja.
8. Environmental Studies by Dr. Suresh K. Dhameja.

C. Expected Course Outcomes :

After successful completion of the course, student will be able to

1. Understand and apply appropriate control and preventive measures for different types of pollutions.
2. Evaluate and apply various industrial laws, acts and audits.
3. Identify various hazards and apply hazard analysis techniques for risk assessment.
4. Analyse safety management system along with safety concepts and safety devices

Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO2160504.1	3	2	2	-	1	3	3	1	1	2	1	2	3	1	1	-
CO2160504.2	-	-	1	1	-	3	3	3	2	2	-	1	2	-	-	1
CO2160504.3	2	2	2	-	-	3	3	-	1	1	-	2	3	-	1	1
CO2160504.4	2	-	2	-	-	3	2	2	1	1	-	2	2	1	1	1

GUJARAT TECHNOLOGICAL UNIVERSITY
CHEMICAL ENGINEERING (05)
CHEMICAL REACTION ENGINEERING - I
SUBJECT CODE: 2160506
B.E. 6th SEMESTER

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
				Theory Marks			Practical Marks			
				PA (M)		PA (V)				
				PA	ALA	ESE	OEP			
3	0	3	6	70	20	10	30	0	20	150

Content:

Sr. No.	Content	Teaching Hrs	Module Weightage (%)
01	Introduction to Reaction Engineering: Classification of reactions, definitions of reactions rate, variables affecting reaction rate, speed of chemical reactions.	4	07
02	Kinetics of homogenous reactions: Simple reactor types, the rate equation, concentration dependent term of rate equation. Molecularity and order of reaction. Rate constant k, representation of an elementary and nonelementary reaction. Kinetic models for nonelementary reactions. Testing kinetic models. Temperature dependant term of rate equations from Arrhenius theory and comparison with collision and transition state theory. Activation energy and temperature dependency. Predictability of reaction rate from theory.	8	15
03	Interpretation of Batch reactor data: Constant volume batch reactor, analysis of total pressure data, Integral and differential methods of analysis of data for constant volume and variable volume cases. Temperature and reaction rate, search for a rate equation.	12	23
04	Introduction to reactor design & Ideal reactors for single reaction: Mass and energy balances around a volume element. Ideal batch reactor, steady-state mixed flow reactor, steady-state plug-flow reactor, holding and space time for flow reactors, space-time and space velocity. Introduction to semi batch reactor.	8	15
05	Design of reactor for single reactions: Size comparison of single reactors, multiple reactor systems, recycle reactor and autocatalytic reactions.	4	7

06	Design for parallel reactions: Introduction to multiple reactions, qualitative and quantitative treatment of product distribution and of reactor size, the selectivity.	4	7
07	Potpourri of multiple reactors: Irreversible first order reactions in series. Quantitative treatment, for plug flow or batch reactor and mixed flow reactor, their performance characteristics, kinetic studies and design. First order followed by zero order reaction, zero order followed by first order reaction, successive irreversible reactions of different orders, reversible reactions, irreversible series-parallel reactions.	7	13
08	Temperature and pressure effects: Single Reactions: Calculations of heats of reaction and equilibrium constants from thermodynamics, equilibrium conversion, general graphical design procedure. Optimum temperature progression, Energy balances equations in adiabatic and non-adiabatic case. Exothermic reaction in mixed flow, Rules for choice of reactors and optimum operation of reactors. Multiple Reactions: Product distribution and temperature.	7	13

Reference books:

1. Octave Levenspiel, Chemical Reaction Engineering, 3rd Edition, Wiley-India Pvt. Ltd.
2. H. Scott Fogler, Elements of Chemical Reaction Engineering, 4th Edition, Prentice hall of India Pvt. Ltd
3. J. M. Smith, Chemical Engineering Kinetics, 2nd edition, McGraw-Hill.
4. L. D. Schmidt, The Engineering of Chemical Reactions, Oxford Press.

Course Outcomes:

After successful completion of the course, student will be able to

1. understand the various types of reactions, reactors, rate equations and their mechanisms.
2. interpret batch reactor data and find the rate equation
3. analyse the performance of batch, CSTR and PFR for isothermal and non-isothermal mode
4. select the best reactor or reactor configurations for maximizing yield and selectivity
5. determine the optimum operating conditions of the reactor considering kinetic & thermodynamic aspects

Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO-1	3	-	-	-	-	-	-	-	2	1	-	1	3	-	-	1
CO-2	3	3	2	1	1	-	-	-	2	1	-	3	2	1	-	1
CO-3	2	3	3	3	2	-	-	-	1	1	-	2	2	2	-	-
CO-4	2	3	2	2	-	-	-	-	1	1	-	2	2	3	1	-
CO-5	3	2	2	2	1	-	1	-	2	1	-	-	2	3	1	1

GUJARAT TECHNOLOGICAL UNIVERSITY

CHEMICAL ENGINEERING (05) ADVANCED SEPARATION TECHNIQUES

SUBJECT CODE: 2160507

B.E. 6th SEMESTER

Teaching and Examination Scheme:

Teaching Scheme			Credits C	Examination Marks						Total Marks
L	T	P		Theory Marks			Practical Marks			
				ESE (E)	PA (M)		ESE (V)		PA (I)	
		PA	ALA		ESE	OEP				
4	0	2	6	70	20	10	20	10	20	150

Content:

Sr. No.	Topic	Teaching Hours	Weightage (%)
1.	Super Critical Extraction Working Principal, Advantage & Disadvantages of supercritical solvents over conventional liquid solvents, Advantage & Disadvantages of supercritical extraction over liquid- liquid extraction, Decaffeination, ROSE process, Commercial applications of supercritical extraction.	06	08
2.	Short path Distillation: Concept & working of short path Distillation Unit (SPDU), Difference between short path Distillation & molecular distillation, applications of SPDU.	06	08
3.	Reactive & Catalytic Distillation: Concept, Advantage & Disadvantages, BALE & KATMAX packing Manufacturing of MTBE and ETBE and it's comparison with conventional techniques.	07	10
4.	Pressure Swing Distillation: Concept & Working, Advantage & Disadvantages of PSD over azeotropic and Extractive Distillation, Applications	04	6
5.	Membrane separation technique: Principles, mechanisms, cross flow, membrane materials and various membrane modules used in membrane separation processes, Classification, application & advantages of membrane separation processes.	08	11
6.	Pressure Swing Adsorption: Concept & Working, Advantages & Disadvantages of PSA over cryogenic distillation, four step PSA, six step PSA, Purification of hydrogen, oxygen, Nitrogen & other commercial applications of PSA.	07	10
7.	Melt crystallization: Concept, phase equilibrium, different techniques, commercial applications	06	8
8.	Reverse Osmosis: Concept of osmosis and reverse osmosis, different types of membrane modules and membrane material for R.O., Advantages and commercial applications of R.O.	06	9

	Ultrafiltration and nano filtration: Concept & working principal ultrafiltration Vs Conventional filtration, Ultrafiltration membranes and modules, Commercial applications of ultrafiltration and nano filtration.	08	10
10.	Pervaporization: Working principal, Advantages, Production of absolute alcohol and other commercial applications.	05	7
11.	Membrane Reactor: Concept & working, Various modules of membrane used for membrane reactor, Advantages & Disadvantages, applications under research	05	7
12.	Membrane or Osmotic Distillation: Working Principal, Various applications, etc.	04	6

Reference Books:

1. "Membrane separation Processes" by Kaushik Nath, PHI pvt. Ltd., 2008
2. "Introduction to process Engineering & Design" by S.B. Thakore & B.I Bhatt, Tata McGraw- Hill Ltd.,2007
3. Perry Chemical Engineers Handbook' 7th Edition by R.H Perry and D. Green.
4. Ullman's Encyclopedia of Industrial Chemistry.
5. "Encyclopedia of Chemical Engineering" by Kirk & Othmer.
6. "Natural Extracts using supercritical carbon dioxide" M. Mukhopadhyay

Course Outcomes:

After successful completion of the course, student will be able to

1. understand the principles and working of various types of advanced separation techniques
2. compare advanced separation techniques with conventional separation techniques
3. analyse a given industrial separation/problem and apply concepts of advanced separation techniques
4. explore use of alternative separation techniques for industrial applications.

Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO2160507.1	3	2	-	-	-	-	-	-	2	1	-	1	2	-	1	1
CO2160507.2	3	2	-	-	-	2	-	-	2	1	-	-	1	-	2	1
CO2160507.3	2	3	-	-	-	1	1	-	3	1	1	-	2	2	-	1
CO2160507.4	3	-	3	2	2	1	2	-	2	2	1	1	1	3	2	2

GUJARAT TECHNOLOGICAL UNIVERSITY

CHEMICAL ENGINEERING (05)

BIOCHEMICAL ENGINEERING

SUBJECT CODE: 2160508

B.E. 6th SEMESTER

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
L	T	P		Theory Marks			Practical Marks			
			ESE (E)	PA (M)		ESE (V)		PA (I)		
PA	ALA	ESE		OEP						
4	0	2	6	70	20	10	20	10	20	150

Contents:

Sr. No.	Topics	Teaching Hours	Weightage %
1	Introduction to Biochemical Engineering Historical background, interdisciplinary approach, Integrated bioprocess systems, Unit Operations in Bioprocess	5	7
2	Microbial Growth Kinetics Batch Culture, Continuous Culture – Multistage systems, Feedback systems, Fed Batch Culture – Variable volume, fixed volume, Cyclic. Applications.	15	21
3.	Design of Fermenter Introduction, Basic Functions, Body construction, Aeration and Agitation, Maintenance of aseptic conditions, Control of parameters, Valves and steam traps, Variants of fermentation vessels.	16	22
4.	Aeration and Agitation Introduction, Oxygen requirement in fermentations, Oxygen supply, Determination of K_{La} values, Fluid Rheology, Factors affecting K_{La} values, Balance between oxygen demand and supply, Scale up and Scale down.	16	22
5.	Basic Outline of fermentation process and purification of fermentation products Introduction, Range of fermentation process, Components of fermentation process, Disruption of cells, precipitation, filtration, Centrifugation, Liquid-Liquid Extraction, Chromatography, Membrane processes, Drying, Crystallization.	20	28

Reference Books:

1. Principles of Fermentation Technology, by Whitaker, Peter F Stanbury, S. Hall and A. Whitaker, Publisher: Butterworth-Heinemann; 2nd edition.
2. Bioprocess Engineering Principles by Pauline Doran, Publisher: Elsevier Science & Technology Books.
3. Introduction to Biochemical Engineering by D. G. Rao, Tata McGraw-Hill Education, 2005.
4. Biochemical Engineering and Biotechnology by Ghasem D. Najafpour, Publisher: Elsevier Science & Technology Books.

Course Outcomes:

After successful completion of the course, student will be able to

1. apply knowledge of biological science and engineering to bio-catalyzed reaction systems
2. evaluate kinetics of biological reactions with the basic understanding in heat and mass transfer
3. select suitable bioreactor for desired application
4. decide suitable separation system for downstream processing

Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO2160508.1	3	3	2	-	-	-	2	-	1	-	-	-	2	-	-	-
CO2160508.2	3	3	2	-	-	1	-	-	-	1	-	-	2	2	1	-
CO2160508.3	3	2	2	-	-	-	1	-	1	2	-	-	2	2	1	-
CO2160508.4	2	1	1	-	-	-	1	-	1	2	-	-	2	-	1	-

understand interdisciplinary approach of Biotechnology and Chemical Engineering.

decide and apply appropriate tools and techniques in biotechnological manipulation.

recognize concepts of animal and plant tissue culture methods and their applications in the field of Biotechnology and evaluate them to facilitate biotechnological advancement and innovations.

justify societal, health, safety and legal issues and understand ones responsibilities in biotechnological engineering practices

GUJARAT TECHNOLOGICAL UNIVERSITY

CHEMICAL ENGINEERING (05)

BIOTECHNOLOGY

SUBJECT CODE: 2160509

B.E. 6th SEMESTER

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
L	T	P		Theory Marks			Practical Marks			
			ESE (E)	PA (M)		ESE (V)		PA (I)		
PA	ALA	ESE		OEP						
4	0	2	6	70	20	10	20	10	20	150

Contents:

Sr. No.	Content	Total Hrs.	% Weight age
1	Introduction to Biotechnology and rDNA technology. Introduction, Old and New Biotechnology, an Interdisciplinary Activity, Scope and Importance, Commercial Potential, Biotechnology in India. Introduction to rDNA technology and genetic engineering, basic techniques and tools. Applications of rDNA technology.	5	7
2	Animal Biotechnology Introduction, The Immune System, Monoclonal Antibodies and Cell Culture Products, In Vitro Fertilization and Embryo Transfer, Babies of a Specified Sex, Animal Cloning, Genome Maps, DNA Fingerprinting in Forensic Medicine	6	8
3	Plant Biotechnology Introduction, History of Tissue Culture Techniques, General Techniques and terminologies. Different culturing techniques, micropropagation, Somaclonal variation, Germplasm conservation.	5	7
4	Biotechnology and Health care Introduction, Disease Prevention (Vaccines), Disease Diagnosis, Disease Treatment, Gene Therapy, Immunodeficiency's, Cancer 417, Forensic Medicine.	6	8
5	General and Industrial Microbiology Introduction, Historical Landmarks, Isolation and Screening of Microorganisms, Maintenance of Isolates/Strains, Inoculum Development, Sterilization, Strain Improvement, Process Development, Downstream Processing, In Situ Recovery of Products, Applications, Metabolite Production, Biotransformation, Recovery of Metals, Biocontrol Agents, Biofertilizers, Genetically Engineered Microbes (GEMS)	12	17
	Enzyme Technology Introduction, Historical, Coenzymes and Cofactors, Enzymes Vs.		

6	Catalysts, Enzymes Vs. Whole Cells, Production of Enzymes, Classification and Nomenclature, Chemical Energetics, Mechanism of Enzyme Action, Enzyme Kinetics, Nontraditional Enzymes, Immobilization of Enzymes, Uses of Enzymes in Solution, Uses of Immobilized Enzymes, Enzyme Reactors, Biosensors, Enzyme Engineering, Bi- and Poly –Functional Enzymes, Safety and Regulatory Aspect.	8	11%
7	Foods and Beverages Introduction, Fermented Foods, Cheese Production, Use of enzymes in Food Industry, Use of Lactase in Dairy Industry, Enzymes in fruit Juice and Brewing Industries, Microbial Biomass, Mushrooms, Single Cell Protein	7	10

Reference Books:

1. Basic Biotechnology by Colin Ratledge and Bjorn Kristiansen, Cambridge University Press, 3rd Edition.
2. Biotechnology by B. D. Singh, Kalyani Publisher.
3. Principles of Fermentation Technology, by Whitaker, Peter F Stanbury, S. Hall and A. Whitaker, Publisher: Butterworth-Heinemann; 2nd edition.
4. Plant Biotechnology by Dr. P. K. Gupta, Rastogi Publication.

Course Outcomes:

After successful completion of the course, student will be able to

1. understand interdisciplinary approach of Biotechnology and Chemical Engineering
2. apply appropriate tools and techniques in biotechnological manipulation
3. recognize and apply the concepts of tissue culture methods and use them
4. justify for societal, health, safety and legal issues, ones responsibility in biotechnological engineering practices

Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO2160509.1	3	1	1	-	-	-	2	-	1	2	-	-	1	-	-	-
CO2160509.2	3	3	2	-	-	1	-	-	1	2	-	-	1	-	-	2
CO2160509.3	3	2	2	-	-	-	1	-	1	2	-	-	1	1	2	-
CO2160509.4	2	1	1	-	-	-	1	-	-	-	-	-	2	1	3	-

GUJARAT TECHNOLOGICAL UNIVERSITY
CHEMICAL ENGINEERING
TRANSPORT PHENOMENA
SUBJECT CODE: 2180507
B.E. 8th SEMESTER

Teaching Scheme			Credits C	Examination Marks						Total Marks
L	T	P		Theory Marks			Practical Marks			
			ESE (E)	PA (M)		ESE (V)		PA (I)		
				PA	ALA	ESE	OEP			
3	0	0	3	70	20	10	0	0	0	100

Content:

Sr.		Total	
1	Introduction to Transport Phenomenon: Classification of Transport Processes, Conservation Laws, Vector and Tensor Calculus	3	5
2	Principles of Momentum Transport: Concept of Viscosity, Newton's Law of Viscosity, Shell Momentum Balance, Application of Shell Momentum Balance, Flow of Falling Film, Flow Through Circular Pipe, Flow Through annulus, Flow Over Moving Plate, Couette Viscometer, Equation of Changes: Continuity Equation, Equation Motion, Navier-Stokes Equation in Cartesian Co-ordinate's and Cylindrical Co-ordinate, Basics of Velocity Distribution	20	37
3	Principles of Steady State Heat Transport: Steady State Condition and Fourier's Law, Shell Energy Balance, Applications of Shell Energy Balance: Heat Conduction with Electrical Source, Heat Conduction with Chemical Heat Source, Temperature Distribution in Two Concentric Cylinder's, Natural Convention Heat Transfer Governing Equation, Flow over Flat Plate	14	26
4	Principles of Mass Transport: Equation of Molecular Mass Transport, Molecular Diffusion in Gases, Equimolar Counter Diffusion, Diffusion of A through Non-Diffusing B, Mass and Molar Transport by Convection: Mass and Molar Concentrations, Mass Average and Molar Average Velocity, Molecular Mass and Molar Fluxes, Convective Mass and Molar Fluxes	17	32

Reference Books:

1. R. Byron Bird, "Transport Phenomena", 2nd Edition, John Wiley & Sons (Asia) pvt. Ltd.
2. Christie John Geankoplis, "Transport Processes and Separation Process Principles", 4th Edition, PHI Learning Private Limited., New Delhi
3. Incropera, "Fundamentals of Heat and Mass Transfer", 6th Edition, John Wiley & Sons (Asia) pvt. Ltd.
4. W.J.Thomson, "Introduction to Transport Phenomena", Pearson Education Asia, New Delhi, 2001.

Course Outcomes:

After successful completion of the course, student will be able to

1. understand the fundamentals of transport phenomena and analogy between different transport phenomena
2. predict transport properties for gases, liquids, solids, and mixtures
3. apply shell balance for energy, mass and momentum transport for various systems and develop mathematical expressions for transport of energy, mass and momentum
4. interpret transport property distribution for various systems

	PO1	PO2	PO3	PO 4	PO 5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO-1	3	-	-	-	-	-	-	-	1	-	-	-	3	-	-	1
CO-2	2	1	-	-	-	-	-	-	2	-	-	-	3	-	-	1
CO-3	3	3	2	-	-	-	-	-	-	-	-	-	3	-	-	-
CO-4	2	3	1	-	-	-	-	-	2	-	-	-	2	-	-	1

BRANCH NAME: Chemical Engineering (05)
PROCESSEQUIPMENTDESIGN-II
SUBJECT CODE:2170502
B.E. 7thSEMESTER

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
				Theory Marks			Practical Marks			
			PA (M)		ESE (V)					
			PA	ALA	ESE	OEP				
4	0	3	7	70	20	10	20	10	20	150

Content:

Sr. No.	Content	Total Hrs	% Weightage
1	Introduction : Concept of internal & external design pressure, design stress & design temperature, Different types of equipments, Static & rotary equipments, Different types of static equipments, Various mechanical properties of material, Different methods of fabrication, Different types of welding joints, Joint efficiency, Radiography.	04	8
2	Mechanical design of Pressure vessel: Introduction of ASME Code sec-VIII, DIV-I & IS-2825, Classification of pressure vessel as per IS-2825, Mechanical design of Shell: shell subjected to internal pressure, Graphical & analytical method for Shell subjected to external pressure, design of shell for external pressure with & without stiffening ring, Different types of head, their selection criteria, Mechanical design of heads: Heads subjected to internal pressure, Graphical & analytical method for heads subjected to external pressure, Different types of Nozzles, their selection criteria, Design of nozzle pipe, Design of reinforcement pad by area for area method, Different types of flanges, Different types of standard flanges, their important features & selection criteria, Different types of flange facings & their selection criteria, Different types of gaskets, their selection criteria, Design of ring flange.	20	37
3	Mechanical design of Reaction Vessel: Mechanical design of shell, head, Jacket, coil, agitator, nozzle, body flange, etc., Different types of agitators & their selection criteria, Different types of agitator shaft sealing system & their selection criteria, Different types of power transmission system, Determination of power required for agitation, shaft diameter, blade thickness, etc., Different types of jackets & their selection criteria, Selection between coil & jacket	06	11
4	Mechanical design of Storage Tank: Classification of storage tank as per IS-803, Capacity of storage tank, its diameter & height, Design of shell and bottom plate for storage tank, Design of Self supported conical roof, Design of structured supported conical roof as per API 620, Selection of column, girders and rafters, Roof curb angel, Floating roof.	05	9

5	Mechanical design of Shell & Tube Heat Exchangers: Mechanical design of Shell, tube, tube sheet, head, channel shell, , etc. of shell & tube heat exchanger	05	9
6	Mechanical design of Vertical tall tower (Distillation Column): Mechanical design of shell, head, tray support, nozzle, body flange, for Vertical tall tower, Determination of shell thicknesses at various heights for tray tower & packed tower in case of internal & external pressure, Different types of tray supports & their selection criteria, design of horizontal structural member with periphery ring type packing support	08	15
7	Supports : Different types of supports, Mechanical design of bracketsupport, skirt, support & saddle support	06	11

Reference Books:

1. Process Equipment Design - Vessel Design - L.E. Brownell & E.H. Young, First Edition.
2. Illustrated Process Equipment Design by S B Thakore, Forth edition,.
3. Process Equipment Design - M.V. Joshi & V.V. Mahajani, Third edition.
4. Process Equipment Design (Mechanical Aspects) By B.C. Bhattacharya.

Course Outcomes:

After successful completion of the course, student will be able to

1. understand fundamentals of mechanical design of process equipment
2. select a suitable material of construction and determine design condition.
3. design process equipment and modify the design of existing equipment to new process conditions or new required capacity.
4. interpret function of process equipment or part of equipment

Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO2170502.1	3	2	1	-	-	-	-	-	1	-	-	1	3	1	-	-
CO2170502.2	3	-	2	-	-	-	-	1	1	-	-	2	2	3	-	-
CO2170502.3	3	1	2	-	2	-	1	1	2	1	1	1	2	3	1	-
CO2170502.4	2	1	1	-	1	-	-	-	1	-	-	1	2	2	-	-
CO2170502	3	2	2	-	2	-	1	1	2	1	1	2	3	3	1	-

GUJARAT TECHNOLOGICAL UNIVERSITY

BRANCH NAME: CHEMICAL ENGINEERING (05)

SUBJECT NAME: ENERGY TECHNOLOGY

SUBJECT CODE: 2170505

B.E. 7th SEMESTER

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
				Theory Marks			Practical Marks			
				PA (M)		PA (V)				
			PA	ALA	ESE	OEP				
3	0	0	3	70	20	10	0	0	0	100

Content:

Sr. No.	Topic	Teaching Hours	(%) Weightage
1.	An Introduction to Energy Sources: Energy sources (conventional & non-conventional), renewable energy resources, primary & secondary energy sources, energy chain, energy demand, national energy strategy & plan, energy management, energy audit & conservation	02	4
2.	Definitions, Units & Measures Proximate & ultimate analysis, calorific values, rank of coal, coking & caking, gasification, basis for reporting results of analysis, units & conversion factors	03	6
3.	Solid Fuels Wood & charcoal, peat, lignite, sub-bituminous & bituminous coals, semi anthracite and anthracite coals, cannel & bog head coal, origin of coal, composition of coal, analysis & properties of coal, problems	03	6

4.	Processing of Solid Fuels Coal preparation, wash ability curve, dry & wet washing methods of coal, washer efficiency, gasification & liquefaction of solid fuels, problems.	04	7
5.	Solar Energy Solar radiation & related terms, measurement of solar radiation, solar energy collectors – flat plate collector, air collector, collectors with porous absorbers, concentrating collectors, applications & advantages of various collectors, selective absorber coatings, solar energy storage systems (thermal, electrical, chemical & mechanical), solar pond, applications of solar energy.	04	8
6.	Wind Energy Basic principles, power in wind, force on blades & turbines, wind energy conversion, site selection, basic components of wind energy conversion systems (WECS), classification of WECS, wind energy collectors, applications of wind energy	04	7
7.	Energy from Biomass Introduction, energy plantation, biomass conversion technologies, photosynthesis, biogas generation, factors affecting biogas generation, classification of biogas plants & their comparisons, types of biogas plants, biogas from plant wastes, community plants & site selection, digester design considerations, design calculations, methods of maintaining & starting biogas plants, properties & utilization of biogas, thermal gasification of biomass, pyrolysis, alternative liquid fuels	05	9
8.	Geothermal Energy Geothermal resources, hydrothermal resources, liquid dominated systems, geopressured resources, petro thermal systems, magma resources, energy conservation & comparison with other resources, applications of geothermal energy	05	9
9.	Energy from Oceans Principle, OTEC, methods (open cycle & close cycle) energy from tides, components of tidal power plants, operation, methods of utilization of tidal energy, storage, ocean waves, wave energy conversion devices	04	8
10.	Fuel Cell Introduction, hydrogen – oxygen fuel cell, ion exchange membrane cell, fossil fuel cell, molten carbonate cell, advantages & disadvantages, conversion efficiency, polarization, type of electrodes, applications of fuel cells	05	9
11.	Hydrogen & Methanol Properties of Hydrogen, production and application of	05	9

	hydrogen, thermochemical methods, fossil fuel methods, solar methods, storage & transportation, safety & management.		
12.	Magneto Hydro-Dynamic (MHD) Power Generation Principle, MHD system, open cycle system, closed cycle system, design problems & developments, advantages, materials for MHD generators, magnetic field & super conductivity	05	9
13.	Nuclear Energy Fission, fusion, fuel for nuclear fission reactor (exploration, mining, milling, concentrating, refining, enrichment, fuel fabrication, fuel use, reprocessing, waste disposal), Nuclear fuel cycle, storage & transportation, uranium enrichment process, nuclear reactor power plant, fast breeder reactor, boiling water reactor, pressurized heavy & light water reactor, Nuclear waste management.	05	9

Reference Books:

1. Fuels & combustion by Samir Sarkar, Orient Longmans (1974)
2. Solar Energy by Sukatame, Tata McGraw Hill, New Delhi
3. Energy Technology by Rao & Parulaker.
4. Energy Sources 2nd Ed. by G. D. Rai, Khanna Publications, New Delhi

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
30	15	15	5	5	0

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Course Outcome: After learning the course the students should be able:

1. **Identify** conventional & non-conventional energy sources.
2. **Analyze** the global scenario of energy sector in terms of demands, supply and management.
3. **Compare** the various methodologies of tapping energy from non-conventional sources.
4. **Devise** application strategies by converting non-conventional energy sources into usable form.
5. **Synthesizing** cost effective power generation and its supply technique in the Industry.

Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO2170505.1	1	1	-	-	-	2	2	-	1	-	-	1	2	-	2	-
CO2170505.2	1	1	-	-	-	1	2	1	1	1	1	2	1	-	1	1
CO2170505.3	2	1	1	-	-	1	1	-	1	-	-	1	1	-	2	-
CO2170505.4	2	2	3	1	-	3	2	1	1	-	1	2	2	3	2	1
CO2170505.5	2	2	2	2	2	1	2	1	1	1	2	2	2	2	2	1

GUJARAT TECHNOLOGICAL UNIVERSITY
BRANCH NAME: Chemical Engineering (05)
Computer Aided Process Synthesis
SUBJECT CODE: 2170507
B.E. 7th SEMESTER

Teaching and Examination Scheme:

Teaching Scheme			Credits C	Examination Marks						Total Marks
L	T	P		Theory Marks			Practical Marks			
			ESE (E)	PA (M)		ESE (V)		PA (I)		
				PA	ALA	ESE	OEP			
4	0	3	7	70	20	10	20	10	20	150

Content:

Sr. No.	Content	Total Hrs	% Weightage
1	The Design Process: Objectives, Design Opportunities, Steps in Product Process Design, Environmental, Protection, Safety Considerations, Engineering Ethics, Role of Computers	8	11
2	Reactor Design and Reactor Network Synthesis: Objectives, Reactor Models, Reactor Design for Complex Configurations, Reactor Network Design Using the Attainable Region	8	11
3	Synthesis of Separation Trains: Objectives, Introduction ,Phase Separation of Reactor Effluent, Criteria for Selection of Separation Methods, Selection of Equipment, Sequencing of Ordinary Distillation for the Separation of Nearly Ideal Marginal Vapour Rate Method,Complex and thermally coupled distillation,Sequencing of Ordinary Distillation for the Separation of Nearly Non-Ideal Fluid Mixtures		

4	Synthesis of Heat Exchanger Networks: Objectives, Basic Heat Exchanger Network Synthesis (HENS), Minimum Utility Targets, Temperature Interval Method, Hohmann / Lochart Composite Curves (HCC), Grand Composite Curves (GCC), Pinch Design Approach to Inventing a Network, Networks for Maximum Energy Recovery, Minimum Number of Exchangers, Stream Splitting, Threshold and Optimum Approach Temperature, Derivation of Network Superstructures for Minimization of Annual Costs, Multiple Utility Design Problems		
5	Energy Integrated Distillation Processes: Heat Integrated Distillation Trains, Impact of Pressure, Multi Effect Distillation, Heat Pumping, Vapour Recompression and Reboiler Flashing, Positioning of Heat Engines and Heat Pumps	8	11
6	Design and Scheduling of Batch Processes: Objectives, Introduction, Design of Batch Process Units, Design of Sequences, Design of Multi-Product Processing Sequencing		

Reference Books:

1. Lorens T. Biegler, E. Ignacio grossmann, Arthur W. Westerberg, Systematic Methods of Chemical Process Design, Prentice Hall International.
2. Warren D. Seider, J. D. Seader, Daniel R. Lewin, Product and Process Design Principles: Synthesis, Analysis, and Evaluation, 2nd Edition, Wiley.
3. Robin Smith, Chemical Process: Design and Integration, Wiley.
4. James M. Douglas, Conceptual Design of Chemical Processes, McGraw Hill International, 1988.

Course Outcome:

After learning the course the students should be able to

1. identify minimum hot and cold utilities and develop heat exchanger networks using pinch design approach.
2. develop reactor network synthesis using attainable region
3. analyse various alternatives for heat integration of distillation columns
4. design batch processes using cycle time for a single/multi product plants
5. develop HENs using various tools

Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO2170507.1	3	3	1	-	-	-	-	-	1	-	-	-	2	2	1	-
CO2170507.2	3	2	2	1	2	-	-	-	2	-	-	1	3	3	1	-
CO2170507.3	2	2	3	2	-	-	1	-	1	-	-	1	2	3	1	-
CO2170507.4	2	2	2	1	1	-	1	-	1	-	1	1	2	2	-	-
CO2170507.5	1	2	1	2	3	-	-	-	2	2	-	1	-	2	2	1

GUJARAT TECHNOLOGICAL UNIVERSITY

Chemical Engineering

NANO TECHNOLOGY

SUBJECT CODE: 2170508

B.E. 7th SEMESTER

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total
L	T	P		C	Theory Marks			Practical Marks		
			ESE		PA (M)		PA (V)		PA	
					PA	ALA	ESE	OEP		
3	0	0	3	70	20	10	0	0	0	100

Content:

Sr. No.	Content	Total Hrs.	% Weightage
1.	Generic methodologies for nanotechnology: classification and fabrication: Introduction and classification, Summary of the electronic properties of atoms and solids, Effects of the nanometer length scale, Fabrication		
2.	Strategies for the scalable synthesis of quantum dots and related Nano dimensional materials –I: Introduction, Defining Nano dimensional Materials, Potential Uses for Nanodimensional Materials, The General Methods Available for the Synthesis of Nanodimensional, Materials, Precipitative Methods, Reactive Methods in High Boiling Point Solvents.	9	16
3.	Strategies for the scalable synthesis of quantum dots and related Nano dimensional materials –II: Reactive methods in high boiling point solvents, hydrothermal and solvothermal Methods.gas-phase synthesis of semiconductor of such methods for scaling		

4.	Nanotechnology and ceramics : Introduction, Synthesis, Vapor Condensation Methods, Sputtering, Laser Method, Spray Pyrolysis, Thermo Chemical /Flame		
5.	Tools to characterize nanomaterials: X-Ray Diffraction (XRD), Scanning Electron Microscopy, Transmission Electron Microscopy, Atomic Force		
6.	Applications of nanomaterials: Cosmetics and Consumer Goods, Nano Sensor, Nano catalysts, Water Treatment and the Environment, Paints, Food and Agriculture		

Reference Books:

1. Nanostructures and Nanomaterials: Synthesis, Properties and Applications by G. Cao, Imperial College Press, 2004.
2. Nanoscale Science and technology by Robert Kelsall (editor), Ian W. Hamley (co-editor), Mark Geoghegan (co-editor) , ISBN: 978-0-470-85086-2
3. The Chemistry of Nanomaterials: Synthesis, Properties and Applications by C. N. R. Rao, A. Muller, A. K. Cheetham, WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim, ISBN: 3-527-30686-2.
4. Nanoscale Materials in Chemistry Edited by Kenneth J. Klabunde, John Wiley & Sons, Inc., ISBNs: 0-471-38395-3 (Hardback); 0-471-22062-0.
5. Textbook of Nanoscience and Nanotechnology, B.S. Muty, P. Shankar, Baldev Raj, B.B Rath and James Murday, University Press, IIM (ISBN-978 81 7371 738 3).
6. Introduction to Nanotechnology by Charles P. Poole Jr and. Frank J. Owens, Wiley-Inter science, 2003.

Course Outcomes:

1. Students will be able to **classify** nano-structured materials and different synthesis techniques.
2. Students will **design** of strategies for scalable synthesis of nano-materials.
3. Students will be **able** to analyze the properties of nano-material using advance tools.
4. Students will **apply** nano-materials in various industries.

Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO-1	3	1	-	-	-	-	-	-	1	1	-	1	2	1	-	-
CO-2	1	1	3	-	-	-	-	-	-	-	-	1	2	1	-	-
CO-3	1	1	-	2	2	-	-	-	-	-	-	1	1	1	2	-
CO-4	1	2	2	2	-	2	1	-	-	-	1	1	2	-	2	-

GUJARAT TECHNOLOGICAL UNIVERSITY
Chemical Engineering (05)
PETROLEUM REFINING AND PETROCHEMICALS
SUBJECT CODE: 2180502
B.E. 8th SEMESTER

Teaching and Examination Scheme:

Teaching Scheme			Credits C	Examination Marks						Total Marks
L	T	P		Theory Marks			Practical Marks			
			ESE (E)	PA (M)		ESE (V)		PA (I)		
				PA	ALA	ESE	OEP			
4	0	2	6	70	20	10	20	10	20	150

Content:

Sr. No.	Content	Total Hrs	Module Weightage
PETROLEUM REFINING			
1	Basic of Petroleum: Role of Crude oil in global economy, Present Scenario of Crude Oil Refinery, Importance, Occurrence, Origin(formation), Exploration, Composition, Classification and Evaluation of Crude oil, Crude Assay Analysis, Distillation Characteristics such as TBP,ASTM&EFV, etc.	06	08
2	Properties of Crude and Petroleum Products: Various types of Average Boiling Points of Crude Oil & Petroleum Fractions. > Types of Gases & their Composition,Types of Gasoline & it's Important Properties and tests such as ASTM Distillation, RVP, Octane Number, Oxidation Stability, Sulphur Content etc, > Various Types of Naphtha and their Important Properties & Applications. > Important Tests & Properties of Kerosene such as Flash& Fire Point,Smoke Point , Aniline Point etc., > Types of Diesel & its Important Properties & Tests such as Pour Point, Diesel Index, Cetane Number etc. Properties such as Viscosity Index, Carbon Residue, Penetration Index, Softening Point etc.	10	14

3	Processing of Petroleum: Pretreatment of Crude (Dehydration & Desalting), Pumping of Waxy Crude, Heating of Crude, Distillation of Petroleum & Types of Reflux, ADU & VDU, Topping Operations etc.	08	11
4	Treatment Techniques: Physical Impurities found in Crude & their Removal, Sweetening Techniques, Production and Treatment of LPG & their Methods, Dehydration and Sweetening of Gases, Gasoline Treatment such as Lead Doctoring, Merox Sweetening, Catalytic Desulphurization etc. Treatment of kerosene, Various Methods of Treatment of Lubes such as Clay Treatment, Phenol Extraction, Furfural Extraction, Dewaxing etc.	09	13
5	Thermal & Catalytic Cracking : Necessity and Types of Cracking Thermal Cracking: Mechanism of Thermal Cracking, Properties of Cracked Materials, Vis Breaking, Dubb's Two Coil Process, Delayed Coking, Naphtha Cracking, etc. Catalytic Cracking: Advantage & Theory of Catalytic Cracking, Fixed bed, Moving Bed & Fluidized Bed Technology, FCC, Hydrocracking, Catalytic Reforming, Platforming, Continuous Catalyst Regeneration Reforming, Catalytic Polymerization, Catalytic Alkylation, Catalytic Isomerization, etc.	09	13
PETROCHEMICALS			
Physical & Chemical Properties, Various Routes of Production, Manufacturing Processes, Flow Sheets, Thermodynamics & Kinetics Consideration & Major Engineering Problems for following Petrochemicals			
6	C1 Petrochemicals: Petrochemicals Obtained from Methanol, Formaldehyde, Chloromethane etc.		
7	C2 Petrochemicals : Petrochemicals obtained from Ethylene, Ethanolamine, Ethylene Dichloride, Vinyl Chloride, Ethylene Oxide, etc.	08	11
8	C3 & Aromatic Petrochemicals : Petrochemicals Obtained from Propylene, ACN, Isopropanol, Cumene, BTX Separation, Phenol, Styrene, Phthalic Anhydride etc.	08	11
9	Polymers: PVC, LDPE, LLDPE, HDPE, Polypropylene, Polypropylene Co-polymers, Polystyrene, SBR, Polyesters, etc.	09	13

Reference books:

1. B. K. Bhaskar Rao, Modern Petroleum Refining Processes, Oxford and IBH 2007 .
2. M Gopal Rao, Dryden's Outlines of chemical technology, 3rd Edition East-West press pvt. Ltd, Delhi
3. B.K. Bhaskar Rao, A Text on Petrochemicals, 2nd Edition, Khanna Publishers, Delhi, 1998

4. George Austin, Shreve's Chemical Process Industries, 5th Edition McGraw Hill publication – New Delhi.
5. W.L.Nelson, Petroleum Refinery Engineering, McGraw Hill, Newyork, 1958.
6. James H, Gary & Glenn E. Handwerk, Petroleum Refining, Technology & Economics,
7. 4th Edition, Marcel Dekker, Inc, 2001.
8. Speight, J. G., The Chemistry and technology of Petroleum, 5th Edition, M. Dekker, 1991.
9. Watkins, R. N., Petroleum Refinery Distillation, 2nd Edition Gulf Pub. Co., Houston, Tex, 1979.

Course Outcome:

After successful completion of the course, student will be able to

1. explain fundamentals of petroleum refinery & various petrochemical plants.
2. build the flow Sheets of various petrochemicals.
3. analyse the basic properties of petroleum products.
4. evaluate various catalytic conversion processes.
5. adapt the recent developments in area of petroleum refining and petrochemical synthesis.

	PO1	PO2	PO3	PO 4	PO 5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO-1	3	2	--	1	--	--	--	--	--	--	--	2	2	--	2	--
CO-2	2	--	--	1	2	--	--	--	1	1	--	1	2	2		1
CO-3	3	1	1		2	1	1	2	2	1	--	2	2	1	2	1
CO-4	2	2	2	3	2	2	2	1	1	--	1	1	2	1	1	--
CO-5	2	3	1	1	1	2	1	--	--	--	--	1	2	--	2	--

GUJARAT TECHNOLOGICAL UNIVERSITY
CHEMICAL ENGINEERING (05)
PROCESS MODELING, SIMULATION & OPTIMIZATION
SUBJECT CODE: 2180503
B.E. 8th SEMESTER

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total
4	0	3	7	70	20	10	20	10	20	150

Content:

Sr. No.	Content	Total Hrs	% Weightage
CHEMICAL PROCESS MODELING			
1	Modeling Aspects: Definition of process model, physical and mathematical modeling, deterministic and stochastic process, classification of models, model building, black-box model, white box model, gray model, classification of mathematical methods.	6	8
2	Mathematical Models of Chemical Engineering Systems: Introduction, uses of mathematical models, scope of coverage, principles of formulation, fundamental laws, continuity equations, energy equations, equation of motion, transport equation, equation of state, equilibrium, kinetics.	7	10

3	Examples of Mathematical Models of Chemical Engineering Systems: Introduction, series of isothermal, constant-hold up CSTR, CSTR with variable holds up, two heated tanks, gas-phase, pressurized CSTR, non-isothermal CSTR, single-component vaporizer, batch reactor, reactor with mass transfer, ideal binary distillation column ,batch distillation with holdup.	11	16
CHEMICAL PROCESS SIMULATION			
4	Partitioning and Tearing: Steady state lumped system-partitioning equation, tearing equation, simultaneous equation, modular approaches & equation solving approaches, decomposition of networks.	6	8
5	Introduction to Various Professional Simulators and Equation Solver Software:	3	4
CHEMICAL PROCESS OPTIMIZATION			
6	The Nature and Organization of Optimization Problems: Scope and hierarchy of optimization, examples of applications of optimization, the essential features of optimization problems, general procedure for solving optimization problems, obstacles to optimization.	4	6
7	Developing Models for Optimization: Classification of models, how to build a model, selecting functions to fit empirical data, factorial experimental designs, degrees of freedom, examples of inequality and equality constrains in models, formulation of the objective function.	6	8
8	Basic Concepts of Optimization: Continuity of function, NLP problem statement, convexity and its applications, interpretation of the objective function in terms of its quadratic approximation, necessary and sufficient conditions for an extremum of an unconstrained function.	6	8
9	Optimization of Unconstrained Functions: One-Dimensional search numerical methods for optimizing a function of one variable, scanning and bracketing procedures, Newton and Quasi-Newton methods of uni-dimensional search, polynomial approximation methods, how one-dimensional search is applied in a multidimensional problem, evaluation of uni-dimensional search methods.	6	8
10	Unconstrained Multivariable Optimization: Methods using function values only, methods that use first derivatives, Newton's method, Quasi-Newton methods.	4	6

11	Linear Programming (LP) and Applications: Geometry of linear programs, basic linear programming, definitions and results, simplex algorithm.	5	7
12	Non Linear Programming (NLP) and Applications: Penalty and Lagrange's method, etc.	3	4
13	Application of Optimizations: Examples of optimization in chemical processes like: optimizing recovery of waste heat, optimal shell and tube heat exchanger design, optimal design and operation of binary distillation column, chemical reactor design and operation.	5	7

Reference Books:

1. B Wayne Bequette, Process Dynamics: Modeling, Analysis and Simulation, Prentice Hall International Inc.
2. B V Babu, Process Plant Simulations, Gulf Publications.
3. William L. Luyben, Process Modeling, Simulation and Control for Chemical Engineers, McGraw Hill International Editions.
4. R Turton, R C Bailie, W B Whiting and J A Shaeiwitz, Analysis, Synthesis and Design of Chemical Processes, Prentice Hall International In.
5. W D Seider, J D Seader and D R Lewin, Product and Process Design Principles-Synthesis, Analysis, and Evaluation, 2nd ed., John Wiley and Sons Inc.
6. Edger, Himmelblau, Lasdon, Optimization of Chemical Processes, McGraw-Hill International Edition.
7. Gordon S. G. Beveridge and Rober S. Schechter, Optimization: Theory and Practice, McGraw-Hill Book Company.
8. K. Deb, Optimization for Engineering Design, Prentice-Hall.
9. MC Joshi and K M Moudgalya, Optimization: Theory and Practice, Narosa Publishing, ISBN: 81-7319-424-6.
10. Nocedal and S J Wright, Numerical Optimization, Springer Verlag. , ISBN:0-387-98793-2.
11. Dimitris Bertsimas, John N. Tsitsiklis, John Tsitsiklis, Introduction to Linear Optimization, Athena Scientific Series in Optimization and Neural Computation,(Book 6), ISBN-10: 1886529191.
12. S. S. Rao, Engineering Optimization: Theory and Practice, Third Edition, Wiley Eastern Ltd.
13. W. F. Ramirez, Computational Methods for Process Simulation, Second Edition, Butterworth-Heinemann

Course Outcome:

1. illustrate use of fundamental laws to develop model for Chemical engineering processes
2. apply mathematical principles and techniques to solve the models for simulation
3. analyse process plant simulation results using professional simulators
4. outline the scope of process optimization and its applications to chemical processes
5. formulate optimization problems and evaluate the solutions

CO's	PO1	PO2	PO3	PO 4	PO 5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO-1	2	-	2	-	-	-	-	1	1	-	-	3	3	1	-	3
CO-2	2	1	1	-	-	1	-	2	-	-	-	3	3	-	-	2
CO-3	2	2	1	3	-	1	-	2	2	-	-	2	2	1	1	2
CO-4	2	2	1	-	-	1	-	2	1	-	-	2	3	1	-	3
CO-5	2	3	2	2	-	-	-	2	1	-	-	2	3	1	1	2

GUJARAT TECHNOLOGICAL UNIVERSITY

BRANCH NAME: CHEMICAL ENGINEERING
SUBJECT NAME: MULTI COMPONENT DISTILLATION
SUBJECT CODE: 2180505
B.E. 8th SEMESTER

Type of course: Chemical Engineering

Prerequisite: Mass Transfer operations, Process Equipment Design

Rationale: The objective of this course is to apply the principles of mass transfer operations to specific applications, separation and/or purification processes which involves multi components. The goal is to provide students with the theoretical/analytical aspects to design multi component distillation equipment and to deal with complex problems of separating multi components.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
L	T	P		Theory Marks			Practical Marks			
			ESE (E)	PA (M)		ESE (V)		PA (I)		
				PA	ALA	ESE	OEP			
3	2	0	5	70	20	10	30	0	20	150

Content:

Sr. No.	Content	Total Hrs	% Weightage
1	Selection of Key Component: Light and heavy key component, Split key and Adjacent key, Distribution of key and non-key components	03	06
2	Sequencing of Distillation Column: Concept, Selection criteria with industrial examples	03	06
3	Selection of Operating Pressure: Determination of operating pressure for the various industrial distillation columns, Criteria for vacuum distillation, Advantages & Disadvantages of vacuum distillation, Determination of vapor-liquid Equilibrium data	06	11
4	Methods for Finding Theoretical Stages : Short cut methods: Fenske-Underwood-Gilliland's method, Rigorous methods: Lewis-Metheson method, Theile-Geddes method, Equation tearing procedures using tridiagonal matrix algorithm	14	26
5	Azeotropic and Extractive Distillation: Concept and Working principle, Industrial examples, Determination of number of theoretical stages for azeotropic and extractive distillation, advantage and disadvantage over each other.	06	11
6	Tower Diameter and Pressure Drop: Criteria of selection between tray tower and packed tower, Various type of packings, Selection of tray type, Determination of tower diameter and pressure	07	13

	drop, Tray Efficiency and HETP.		
7	Multicomponent Batch Distillation: Design of multicomponent batch distillation with and without rectification.	07	13
8	Energy Saving in Distillation : Optimum design of system, Use of high efficiency trays, Heat integration, Advanced process control, Thermally coupled distillation column, Use of heat pumps, Efficient operation of distillation column, Replace the distillation partially or completely with New separation techniques	08	14

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
7	21	21	7	14	

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. Introduction to Process Engineering & Design by S.B.Thakore & B.I. Bhatt. Tata McGraw-Hill, 2007.
2. Distillation dynamics and control by P.B. Deshpande, Arnold USA 1985.
3. Perry's chemical engineers handbook, 7th edition, McGraw-Hill, USA, 2000.
4. Distillation design by H.Z.Kister, , McGraw-Hill, USA,1992.
5. Equilibrium-stage separation operation in chemical engineering by Ernest J. Henley and J.D. Seader.
6. Coulson and Richardson's Chemical Engineering Volume 6 (Design), 2nd Edition, by R.K. Sinnott, Pergamon Press, Oxford, UK (1993).

Course Outcome:

After learning the course the students should be able to:

- Select key component
- Calculate number of theoretical and actual stages required for multi component distillation by using various methods.
- Understand how to break azeotrope using azeotropic and extractive distillation.
- Determine reflux ratio required for the distillation operation.
- Calculate tower diameter and operating pressure for multi distillation column.
- Understand various design options for energy conservation in distillation column.

List of Tutorials:

Students can identify problems related to its design and application in current industries. Students can modify the design or can suggest the changes required for better operation in terms of economy and efficiency. Students can also optimize the equipment for better results and data collection. Students need to prepare a report on the same topic and also to prepare power point presentation on the same.

List of Open Source Software/learning website:

- ✓ Students can refer to video lectures available on the websites including NPTEL lecture series.
- ✓ Students can refer to the CDs available with some reference books for the solution of problems using software's/spreadsheets. Students can develop their own programs/spreadsheets for the solution of problems.

ACTIVE LEARNING ASSIGNMENTS: Preparation of power-point slides, which include videos, animations, pictures, graphics for better understanding theory and practical work – The faculty will allocate chapters/ parts of chapters to groups of students so that the entire syllabus to be covered. The power-point slides should be put up on the web-site of the College/ Institute, along with the names of the students of the group, the name of the faculty, Department and College on the first slide. The best three works should submit to GTU.

GUJARAT TECHNOLOGICAL UNIVERSITY
CHEMICAL ENGINEERING
TRANSPORT PHENOMENA
SUBJECT CODE: 2180507
B.E. 8th SEMESTER

Teaching Scheme			Credits C	Examination Marks						Total Marks
L	T	P		Theory Marks			Practical Marks			
			ESE (E)	PA (M)		ESE (V)		PA (I)		
				PA	ALA	ESE	OEP			
3	0	0	3	70	20	10	0	0	0	100

Content:

Sr.		Total	
1	Introduction to Transport Phenomenon: Classification of Transport Processes, Conservation Laws, Vector and Tensor Calculus	3	5
2	Principles of Momentum Transport: Concept of Viscosity, Newton's Law of Viscosity, Shell Momentum Balance, Application of Shell Momentum Balance, Flow of Falling Film, Flow Through Circular Pipe, Flow Through annulus, Flow Over Moving Plate, Couette Viscometer, Equation of Changes: Continuity Equation, Equation Motion, Navier-Stokes Equation in Cartesian Co-ordinate's and Cylindrical Co-ordinate, Basics of Velocity Distribution	20	37
3	Principles of Steady State Heat Transport: Steady State Condition and Fourier's Law, Shell Energy Balance, Applications of Shell Energy Balance: Heat Conduction with Electrical Source, Heat Conduction with Chemical Heat Source, Temperature Distribution in Two Concentric Cylinder's, Natural Convention Heat Transfer Governing Equation, Flow over Flat Plate	14	26
4	Principles of Mass Transport: Equation of Molecular Mass Transport, Molecular Diffusion in Gases, Equimolar Counter Diffusion, Diffusion of A through Non-Diffusing B, Mass and Molar Transport by Convection: Mass and Molar Concentrations, Mass Average and Molar Average Velocity, Molecular Mass and Molar Fluxes, Convective Mass and Molar Fluxes	17	32

Reference Books:

1. R. Byron Bird, "Transport Phenomena", 2nd Edition, John Wiley & Sons (Asia) pvt. Ltd.
2. Christie John Geankoplis, "Transport Processes and Separation Process Principles", 4th Edition, PHI Learning Private Limited., New Delhi
3. Incropera, "Fundamentals of Heat and Mass Transfer", 6th Edition, John Wiley & Sons (Asia) pvt. Ltd.
4. W.J.Thomson, "Introduction to Transport Phenomena", Pearson Education Asia, New Delhi, 2001.

Course Outcomes:

After successful completion of the course, student will be able to

1. understand the fundamentals of transport phenomena and analogy between different transport phenomena
2. predict transport properties for gases, liquids, solids, and mixtures
3. apply shell balance for energy, mass and momentum transport for various systems and develop mathematical expressions for transport of energy, mass and momentum
4. interpret transport property distribution for various systems

	PO1	PO2	PO3	PO 4	PO 5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO-1	3	-	-	-	-	-	-	-	1	-	-	-	3	-	-	1
CO-2	2	1	-	-	-	-	-	-	2	-	-	-	3	-	-	1
CO-3	3	3	2	-	-	-	-	-	-	-	-	-	3	-	-	-
CO-4	2	3	1	-	-	-	-	-	2	-	-	-	2	-	-	1

GUJARAT TECHNOLOGICAL UNIVERSITY

BRANCH NAME: Chemical Engineering

SUBJECT NAME: SOLID FLUID OPERATIONS

SUBJECT CODE: 2180508

B.E. 8th SEMESTER

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
				Theory Marks			Practical Marks			
			PA (M)		ESE (V)					
			PA	ALA	ESE	OEP				
3	2	0	5	70	20	10	30	0	20	150

Content:

Sr. No.	Topic	Teaching Hours	Module Weightage (%)
1	Introduction: Solid- Fluid operations, characterization and classification.	4	7
2	Mixing and agitation: Mixing, Agitation, Different types of agitators and their selection criteria, Calculation of power required for agitation, Scale up of agitated vessel, static mixers, intensive mixers, heating and cooling mixers.	8	14
3	Fluidization: Fluid flow in porous solid beds, Conditions for Fluidization, Types of fluidization, Applications of fluidization	9	16
4	Transportation: Mechanic, Slurry, hydraulic and pneumatic transport, conveyors.	8	15
5	Filtration and sedimentation: Cake filters, Constant rate filtration, constant pressure filtration,	10	18

	Filter press, Shell and leaf filters, vacuum filters, Centrifugal filters, Filter media, Filter aids, Clarifying filters, Gravity classifiers, Sink and float method, Clarifiers and thickeners, Batch sedimentation, Rate of sedimentation, Thickeners, Cyclones, Hydrocyclones, Centrifuges.		
6	Solid- Fluid Mass Transfer: Leaching, Crystallization, Nucleation, Growth of crystals, Drying.	8	15
7	Solid- Fluid Reactors: Fluidized bed reactor, moving bed reactor, slurry bed reactor, fixed bed reactor.	7	15

Reference Books:

1. Introduction to Chemical Engineering by W. L. Badger & J.T. Banchero.
2. "Mass transfer operation" by R. E. Treybal, Mc-Graw Hill International
3. G. G. Brown, Unit Operations, CBS Publishers & Distributors, 2005.
4. J. F. Richardson, J. H. Harker, J. R. Backhurst, Coulson and Richardson's Chemical Engineering, vol. 2, 5thed., Butterworth, 2002.
5. C. J. Geankoplis, Transport Processes and Separation Process Principles, 4thed., Prentice-Hall, 2003.
6. J. D. Seader, E. J. Henley, Separation Process Principles, 2nded., John Wiley & Sons, 2006.
7. Don W. Green, Robert H. Perry: Perry's Chemical Engineers' Handbook, eighth edition.
8. Unit Operations of Chemical Engg. By W.L. McCabe, J. C. Smith & Harriott, 6th Edition Mc-Graw Hill International.

Course Outcome:

1. Students should be able to **compare** the various solid fluid operations.
2. Students should be able to **apply** the solid fluid operations in chemical industries for drying, crystallization, leaching, mixer, filter, cyclone & fluidized bed reactor.
3. Students should be able to **design** Agitator, mixer, filter, cyclone separator, fluidized bed Reactor & other solid fluid operation units.
4. Students can **evaluate** the performance of various solid-fluid operations.

Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO-1	2	2	-	-	-	-	-	-	-	-	-	-	2	-	2	-
CO-2	2	-	1	1	1	1	-	-	-	-	-	1	2	1	-	-
CO-3	2	2	3	2	-	-	-	-	1	-	-	-	2	3	-	-
CO-4	2	2	2	3	1	1	-	-	1	-	-	1	2	1	1	-

GUJARAT TECHNOLOGICAL UNIVERSITY
Chemical Engineering (05)
Fertilizer Technology
SUBJECT CODE: 2180509
B.E. 8th SEMESTER

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks					Total Marks	
				Theory Marks		Practical Marks				
						PA (M)		ESE (V)		
						PA	AL A	ESE	OEP	
3	2	0	5	70	20	10	30	0	20	150

Content:

Sr. No.	Content	Total Hrs	% Weightage
1	<p>Overview of Fertilizer: Synthetic fertilizers, Classification of fertilizers, Role of essential Elements in plant Growth, Macro elements and Micro elements, Application of fertilizers considering Nutrient, Balance and types of crop. Development of fertilizer industry; Fertilizer production and consumption in India; Nutrient contents of fertilizers; Secondary nutrients; Feedstock and raw materials for nitrogenous, phosphatic and potassic fertilizers.</p>	8	14
2	<p>Nitrogenous Fertilizers: Introduction to Ammonia: Physical & chemical properties, applications, Synthesis gas by Catalytic partial oxidation Steam Hydrocarbon reforming, Ammonia converters: Design aspect of Single bed and multi-bed converter, Kellogg process and HaldorTopsoe process, Storage and Transportation of Ammonia. Introduction to Nitric acid: Chemical, physical properties and applications, Manufacturing of Nitric Acid by Pressure ammonia oxidation process and Intermediate pressure ammonia oxidation process, Concentration of Nitric acid by Mg(NO₃)₂.</p>	22	36

	Urea: Physical, chemical properties, Manufacturing of Urea by Stamicarbon's CO ₂ stripping process, Toyo-Koatsu total recycle process, Manufacturing of Ammonium nitrate by Prilling process, Ammonium sulphate from Ammonium carbonate and gypsum, Ammonium chloride from Ammonium sulphate and sodium chloride		
3	Potassium Fertilizers: Physical, chemical properties and uses of Potassium Chloride, Potassium nitrate, Potassium sulphate, Manufacturing of potassium chloride from sylvinit, Preparation of Potassium nitrate, Potassium sulphate.	12	25
4	Miscellaneous Fertilizer and Bio Fertilizers: Manufacturing of NPK, Ammonium Sulphate Phosphate (ASP), Calcium Ammonium Nitrate(CAN), Biofertilizers, Types of Biofertilizers, Nitrogen- fixing biofertilizers, Phosphate-solubilizing biofertilizers, Preparation of a biofertilizers	12	25

Reference Books:

1. Hand book of Fertilizer Association of India, New Delhi, 1998.
2. Slack A.V., Chemistry & Technology of Fertilizers, Interscience, New York, 1967.
3. M. Gopala Rao & Marshall Sittig, Dryden's Outlines of Chemical Technology, East-West Press, 3rd Edition, New Delhi.
4. Austin G. T, Shreve's Chemical Process Industries, 5th edition, Mc. Graw Hill Publications.
5. Pandey & Shukla, Chemical Technology, Volume I & II, 2nd Edition, Vani Books Company.
6. N S Subba Rao, Bio fertilizers in Agriculture, Oxford & IBH Publishing Company.

Course Outcome:

After successful completion of the course, student will be able to

1. understand various processes used in fertilizers industries.
2. understand various processes used in fertilizers industries.
3. evaluate unit operations & unit operations and their engineering problems in manufacturing of various fertilizers.
4. acquire the knowledge of bio fertilizers and their applications

	PO1	PO2	PO3	PO 4	PO 5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO-1	3	3	-	-	-	-	-	-	-	-	-	-	3	-	2	-
CO-2	3	-	-	-	-	2	2	-	3	3	-	1	2	-	2	-
CO-3	3	1	-	-	-	2	1	-	-	-	-	-	3	-	2	-
CO-4	2	2	-	-	-	-	-	-	-	-	-	-	1	-	-	1
CO-5	3	3	-	-	-	2	2	-	3	3	-	1	3	-	2	1

- Characterize fertilizers on the basis of different properties.
- Identify engineering problems in fertilizer manufacturing.
- Handle the fertilizers.
- Select appropriate synthesis fertilizer.

List of Open Source Software/learning website:

- Students can refer to video lectures available on the websites including NPTEL lecture series.
- Students can refer to the CDs available with some reference books for the solution of problems using software/spreadsheets. Students can develop their own programs/spreadsheets for the solution of problems.
- MIT Open course lecture on Equipment design used in fertilizer Technology.

ACTIVE LEARNING ASSIGNMENTS: Preparation of power-point slides, which include videos, animations, pictures, graphics for better understanding theory and practical work – The faculty will allocate chapters/ parts of chapters to groups of students so that the entire syllabus to be covered. The power-point slides should be put up on the web-site of the College/ Institute, along with the names of the students of the group, the name of the faculty, Department and College on the first slide. The best three works should submit to GTU.