CHAITANYA BHARATHI INSTITUTE OF TECHNOLOGY(A)

Model Curriculum (with effect from 2019-20)

B.TECH (Chemical Engineering)

SEMESTER – V

S.No	Course Code	Title of the Course	Scheme of Instruction			Scheme of Examination			Credits
			Hours per week			Duration of SEE in Hours	Maximum Marks		
			L	T	P/D		CIE	SEE	
	THEORY								
1	18CH C10	Chemical Reaction Engineering I	3	-	-	3	30	70	3
2	18CH C11	Mass Transfer I	3	-	-	3	30	70	3
3	18CH C12	Heat Transfer	3	1	-	3	30	70	4
4	18CH C13	Particle and Fluid Particle Processing	3	-	-	3	30	70	3
5		Core Elective I	3	-	-	3	30	70	3
6		Core Elective II	3	-	-	3	30	70	3
	PRACTICALS								
7	18CH C14	Chemical Engineering Lab IA-MUO	-	-	3	3	15	35	1
8	18CHC15	Chemical Engineering Lab IB-FM and HT	-	-	3	3	15	35	1
Total			**18**	**01**	**06**	**-**	**210**	**490**	**21**

L:Lecture T:Tutorial D:Drawing P: Practical

CIE – Continuous Internal Evaluation SEE- Semester End Examination

Core Elective I		Core Elective II	
18CH E 01	Water Conservation and Management	18CH E 04	Polymer Science and Technology
18CH E 02	Renewal Energy	18CH E 05	Green Technology
18CH E 03	Experimental and Analytical Techniques	18CH E 06	Catalysis

18CH C10 **CHEMICAL REACTION ENGINEERING I**

Instruction	3Hours per week
Duration of SEE	3 Hours
SEE	70 Marks
CIE	30 Marks
Credits	3

Course Objectives: This course helps the students to

1. Analyze experimental kinetic data to determine reaction mechanisms.
2. Design different types of chemical reactors (Batch, Tube, and CSTR).
3. Assess the advantages and disadvantages of reactor types.
4. Understand the concepts of non ideal reactors.

Course Outcomes: At the end of the course students will be able to

1. Classify reactions, rate and forms of rate expressions.
2. Summarize fundamentals of kinetics and interpret the data including relationships between moles, Concentration, extent of reaction and conversion.
3. Explain Batch, CSTR, and PFR performance equations from general material balances for homogeneous and heterogeneous reactions.
4. Identify the right reactor among single, multiple, recycle reactors etc.
5. Apply the concepts of heat effects on reactions.
6. Analyze the non ideality of reactors.

UNIT-I

Introduction: Classification of Reactions, Definition - Variables affecting the rate of reaction. The rate equation and Stochiometric relations for a single phase reaction $aA+bB \rightarrow rR+sS$. Single and multiple reactions, Elementary and non-Elementary reactions, Molecularity and order of Reaction, Specific reaction rate constant, Testing kinetic models – Steady state approximation, Equilibrium treatment, Fitting a rate law for the given reaction mechanism, predictability of reaction rate from theory. Temperature dependency from Arrhenius' law, Thermodynamics, Collision theory and Transition state theory, Comparison of theories with Arrhenius' law.

UNIT-II

Analysis and Correlation of experimental kinetic data: Constant volume batch reactor: Analysis of total pressure data, conversion. Integral method of analysis of data for single reaction, multiple reactions, Homogeneous catalyzed reactions, Auto catalytic reactions, Reversible reactions, and Reactions of shifting orders. Half life method, Partial analysis of the rate equation .Differential method of analysis of data.

Variable Volume Batch Reactor: Fractional change in volume of the system, Differential method of analysis, Integral method of analysis.

UNIT-III

Introduction to Reactor Design: Ideal reactors for a single reaction, generalized material balance, design equations-Ideal batch reactor, Space time – space velocity, Steady state mixed flow reactor, Steady state plug flow reactor, Holding time and space time for flow reactors, graphical interpretation. Design for single reactions, Size comparison of single reactors, Multiple reactor systems, Recycle reactor, Auto catalytic reactions – optimum recycle operation, Reactor combinations.

UNIT-IV

Design for Multiple Reactions: Series, Parallel and Independent reactions, Selectivity, Yield, Qualitative discussion about product distribution, Quantitative treatment of product distribution and of reactor size.

Temperature and Pressure effects for single reactions, Heat of reaction from thermodynamics, Heat of reaction and Temperature, Equilibrium constants and equilibrium conversions from Thermodynamics. General graphical design procedure, Optimum temperature progression. Heat effects, Adiabatic Operations, Non adiabatic operations. Exothermic reactions in mixed flow reactors – a qualitative treatment.

UNIT-V

Basics of Non-Ideal flow: The residence time distribution (R T D), State of aggregation of the flowing stream, earliness of mixing, Role of R T D, state of aggregation and earliness of mixing in determining reactor behavior. Exit age distribution of fluid, Experimental methods for finding E – pulse and step input experiments, Relationship between F and E curves. The convolution integral. Conversion in non- ideal flow reactors, Dispersion model-Axial dispersion and correlations for axial dispersion.

Text Books:

1. Octave Levenspiel, Chemical reaction Engineering, 3rd Ed, Wiley India Pvt.Ltd, New Delhi, 2006.

Suggested Reading:

1. J. M. Smith, Chemical Engineering Kinetics, McGraw – Hill , Third Edition, 1981
2. H. Scott Fogler, Elements of Chemical Reaction Engineering, Prentice Hall, Third Edition, 2002.

18CH C11 **MASS TRANSFER I**

Instruction	3Hours per week
Duration of SEE	3 Hours
SEE	70Marks
CIE	30Marks
Credits	3

Course Objectives: This course helps the students to understand

1. Steady state, unsteady state diffusion mass transfer and determination of diffusivity in gas and liquids.
2. Mass transfer coefficients based on different mass Transfer Theories and their correlations with different analogies.
3. Description of Continuous and stage wise contact equipment- gas absorption and their equilibrium stages, number of transfer units.
4. Concept of distillation mass transfer operation and design the distillation column.
5. Concept of multi component distillation, azeotropic distillation and extractive distillation.

Course Outcomes: At the end of the course students will be able to

1. Apply the concepts of diffusion mass transfer to liquids and solids.
2. Estimate the mass transfer coefficients.
3. Design gas absorber by equilibrium method to find the number of theoretical stages.
4. Estimate the number of theoretical stages of distillation column using McCabe- Thiele and Ponchan-Savarit methods.
5. Explain extractive distillation and azeotropic distillation.

UNIT-I

Introduction: Diffusion and Mass Transfer – Mass transfer operations & their applications. Constitutive laws of diffusion, Molecular diffusion –Fick's first law – steady state molecular diffusion in binary3-\ mixtures of gases, liquids and solids – Determination of diffusivity in gases by Stefan-Maxwell method: estimation of diffusion coefficients in binary mixtures of liquids and gases by correlation; unsteady state diffusion

UNIT-II

Mass transfer coefficients: Convective mass transfer, inter phase mass transfer and mass transfer coefficients, Penetration theory, Surface Renewal Theory, Boundary Layer Theory. Mass transfer correlations for mass transfer coefficients and Reynolds & Colburn analogies. Effect of chemical reaction on mass transfer

UNIT-III

Gas – liquid contact: Description of Continuous and stage wise contact equipment, Equilibrium stages and transfer units: number and height of transfer units; stage efficiency.

Gas absorption plate and packed column design: Absorption and Stripping: counter current and co-current isobaric absorption and stripping of single component – Operating Lines – Minimum flow rates – Determination of number of plates – absorption factor. Determination of number of transfer units and height of a continuous contact plate and packed absorbers. Kremser – Brown equation for tray towers and packed towers, reactive absorption.

UNIT-IV

Distillation: VLE Phase diagrams – Tie lines and mixture rule – Flash vaporization and differential distillation for binary mixtures – Steam distillation. Batch distillation with reflux for binary mixtures. Continuous fractionation of binary mixtures, Ponchan – Savarit method, McCabe – Thiele method for determination of ideal plates for binary mixtures, Optimum reflux ratio, Use of total and partial condensers. Use of open steam, Packed bed distillation

UNIT-V

Introduction to multi component distillation, azeotropic distillation, extractive distillation

Text Books:

Binay K Dutta, Principles of Mass Transfer and Separation Processes,2nd edition, Prentice Hall of India,2007
R E Treybal, Mass Transfer Operations, 3rd Edition, McGraw Hill, New Delhi, 1983

Suggested Reading:

C.J. Geankoplis, Transport Processes and Unit Operations, 3rd Edition, Prentice Hall, India, 1993

18CH C 12 **HEAT TRANSFER**

Instruction	3L+1T Hours per week
Duration of SEE	3 Hours
SEE	70 Marks
CIE	30 Marks
Credits	4

Course Objectives: This course will help the students to understand the

1. Basic concepts of heat transfer
2. Convective Heat Transfer and the concept of dimensional analysis
3. Concept and functioning of different heat exchangers
4. Heat transfer with change of phase and the functioning of evaporators
5. Radiation Laws and the concept of radiation shields, Design aspects of furnaces.

Course Outcomes: At the completion of this course students will be able to

1. Distinguish between different types of heat transfer
2. Analyze and understand the concepts of Heat exchangers
3. Calculate the rate of heat transfer with and without change of phase
4. Identify the type of evaporator required for a specific purpose and design it
5. Explain the impact of radiation shields and design aspects of furnaces.

UNIT - I

Fundamentals of Heat Transfer :- Modes of Heat Transfer, Derivation of Heat conduction equations in rectangular co-ordinates, thermal diffusivity, Differential equations of heat transfer-special forms – cylindrical co-ordinates system. One dimensional problem, heat transfer from extended surfaces, two dimensional problems, Lumped capacity systems, Insulation.

UNIT - II

Convective Heat Transfer: - Natural and forced convection in laminar and turbulent flow over plates and tubes. Dimensional Analysis, Thermal Boundary layer, Analogies and correlations. Design of Heat Transfer Equipment - Double Pipe Heat Exchanger, Concept of LMTD, Shell and tube Exchanger – Kern's method of design, Effectiveness - NTU methods, construction aspects in brief.

UNIT - III

Design aspects of finned tube and other compact heat exchangers. Basics of Heat Transfer with change of phase - Introduction to boiling. Types of boiling, Regimes of pool boiling and critical heat flux. Nucleate Boiling-Bubble formation, its growth and motion Introduction to condensation.

UNIT - IV

Derivation of Nusselt's equation. Design aspects of Condensers. Types of Evaporators, Capacity and Economy of Evaporators, Design aspects of Evaporators – Material and energy Balances of single and multiple effect evaporators. Heat Transfer to agitated vessels. Description and working of crystallizers

UNIT - V

Radiation – Fundamentals of Radiation Heat Transfer. Laws of black body Radiation. Radiation Shields .Radiating heat exchange between non black body surfaces. Design aspects of furnaces.

Text Books:

1. W.L.McCabe, J.C.Smirh and P.Harriott, 'Unit Operations of Chemical Engineering' 7th Edition,Tata-McGraw Hill, New Delhi , 2005
2. D.Q. Kern, 'Process Heat Transfer'1st Edition Tata-McGraw Hill Publishers, New Delhi, 2001
3. Holman, J.P.S. Bhattacharya. Heat Transfer, 10th Edition, Tata-McGraw Hill, 2011

Suggested Reading:

1. Coulson JM and Richardson, J.F, Chemical Engineering Series,Vol 1, 4th Edition, Pergamon Press Oxford, UK, 1991
2. B K Dutta, Heat Transfer Principles and applications, PHI Learning Pvt Ltd, New Delhi, 2004
3. C P Gupta and Rajender Prasad, Engineering Heat Transfer, NemChand and Brothers , New Delhi, 2010

18CH C 13 **PARTICLE AND FLUID-PARTICLE PROCESSING**

Instruction	3 Hours per week
Duration of SEE	3 Hours
SEE	70 Marks
CIE	30 Marks
Credits	3

Course Objectives: This course will help the students to understand the

1. Numerous industrial operations dealing with the particulate solids, their handling in various unit operations, and those in which particle-fluid interactions are important.
2. Fundamentals of fluid-particle mechanics, such as the notion of drag, and builds on those fundamentals to develop design concepts for various industrial processes like packed bed operation, fluidized operations, sedimentation, filtration, separation of solids and fluids, etc.
3. Industrial applications
4. Colloidal systems, soft materials and nano particles. Applications of these novel systems are discussed.
5. Concepts of Filtration and transport of fluid-solid systems

Course outcomes: After the completion of the course students will be able to

1. Identify and describe fluid-particle systems in terms of their basic physical properties
2. Explain size reduction energy requirements, estimate performance of equipment, selection and sizing of equipment.
3. Find drag force and terminal settling velocity for single particles.
4. Determine pressure drop in fixed and fluidized beds.
5. Apply separation techniques sedimentation, flocculation to separate a solid fluid mixtures
6. Analyze filtration data and select systems based on requirements, estimate filtration area for given requirements, understand filter aids and their usage.

UNIT- I

Introduction: Relevance of fluid and particle mechanics, and mechanical operations, in chemical engineering processes.

Introduction to nanoparticles: Properties, characterization, synthesis methods, applications.

Solid particle characterization: Particle size, shape and their distribution; Relationship among shape factors and particle dimensions; Specific surface area; Measurement of surface area. Size reduction, milling, laws of communition, classification of particles.

Size enlargement; Nucleation and growth of particles

UNIT- II

Flow around immersed bodies: Concept of drag, boundary layer separation, skin and form drag, drag correlations

Packed bed: Void fraction, superficial velocity, channeling, Ergun equation and its derivation, Kozeny Carman equation, Darcy's law and permeability, Blaine's apparatus.

UNIT- III

Fluidization: Fluidized bed, minimum fluidization velocity, pressure drop, Geldart plot etc. Types of fluidization: Particulate fluidization, Bubbling fluidization, Classical models of fluidization, circulating fluidized beds, Applications of fluidization.

UNIT- VI

Separation of solids from fluids: Introduction

Sedimentation: Free Settling, hindered settling, Richardson-Zaki equation, design of settling tanks.

Colloidal particles: stabilization, flocculation.

Centrifugal separation, design of cyclones and hydro cyclones

UNIT- V

Filtration: Concepts, design of bag filters, design of electrostatic filters.

Transport of fluid-solid systems: pneumatic and hydraulic conveying.

Text Books:

1. McCabe W, Smith J and Harriott, P. Unit Operations of Chemical Engineering, 6th edition, McGraw Hill
2. Coulson and Richardson's Chemical Engineering, Vol. 2, Butterworth-Heinemann, 5th edition 2002

Suggested Reading:

1. Rhodes M J, Introduction to Particle Technology, 2nd edition, John Wiley, Chichester; New York, 2008
2. Allen T, Powder Sampling and Particle Size Determination, Elsevier, 2003
3. Masuda H, Higashitani K., Yoshida H, Powder Technology Handbook, CRC, Taylor and Francis, 2006
4. Vollath D, Nanomaterials: An Introduction to Synthesis, Properties and Applications, 2nd Ed., Wiley, 2013

18CH E 01 **WATER CONSERVATION AND MANAGEMENT**
(Core Elective I)

Instruction	3Hours per week
Duration of SEE	3 Hours
SEE	70Marks
CIE	30Marks
Credits	3

Pre-requisites: Environmental science (mandatory non-credit course)

Course Objectives: This course helps the students to understand:
1. Water sources, usage and need to protect them.
2. Water quality and standards
3. Water audits and testing methods.
4. Water management system.
5. Need for water conservation.

Course Outcomes: At the completion of this course, students will be able to
1. Identify the water storage methods in practice based on available sources and supply.
2. Understand the water quality parameters and analysis methods.
3. Classify the basic characteristics of water and their testing methods.
4. Explain the objectives of water harvesting and recycling methods.
5. Make use of water conservation methods at work place, agriculture, service and process industry.

UNIT – I Introduction:
Sources of water, Hydrologic cycle, multiple cycles – evaporation, precipitation, infiltration, runoff and subsurface flow. Composition of water sources like sea, rain, snow, river, lake. Need to protect water supplies, sources of water supply, types of water storage systems in practice.

UNIT – II Water quality and standards:
Physical, chemical and microbiological quality characteristics of water, water quality classification system in India, water quality parameters, standards of drinking water prescribed by different agencies, permissible limits of constituents of raw water supplied to industries, tolerance limits of industrial effluents, tolerance limits of inland surface water.

UNIT – III Water audits and testing:
Water rights and laws, water policy objectives, water quality related issues in India, major factors for water quality degradation, water quality – testing, preserving and control methods. Analysis of water –Physical, chemical and bacteriological tests practiced.

UNIT – IV Water management:
Water management services in India, key issues and principles of water management, integrated water resource management in India. Necessity and objectives of watershed management, approaches and practices, types of water harvesting– afforestation and rainwater harvesting, benefits, identifying locations. Water recycling – benefits, reuse drives.

UNIT – V Water conservation:
Water use, impacts and benefits, Water conservation methods, minimizing evaporation, water conservation practices and case studies in fields of agriculture, work place, service industry, process industry.

Text Books:
1. Elements of Water Pollution Control Engineering, OP Gupta, Khanna Publishing House, Delhi, 2019.
2. Glenn O. Schwab and R K Frevert, Water Conservation and Management Soil and Water Conservation Engineering, 3rd Ed., John Wiley & Sons, 1981

Suggested reading:
1. Water Supply and Sanitary Engineering, Rangwala, Charotar Publications, 2006.

18CH E 02 **RENEWABLE ENERGY**
(Core Elective I)

Instruction	3Hours per week
Duration of SEE	3 Hours
SEE	70Marks
CIE	30Marks
Credits	3

Course Objectives: This course will help the students to understand
1. Concept of various forms of Renewable energy resources and Non-Renewable energy resources.
2. Outline division aspects and utilization of renewable energy sources for both domestics and industrial applications.
3. Identify Wind energy as alternate form of energy and to know how it can be tapped.
4. Concepts of thermo and bio-chemical process along with novel technologies to conversion of biomass to Bio fuel.
5. Environmental and cost economics of using renewable energy sources.

Course Outcomes: At the end of the course students will be able to
1. Describe the environmental aspects of non-conventional energy resources compared with various conventional energy systems, their prospects and limitations.
2. Explain the use of solar energy and the various components used in the energy production with respect to applications.
3. Find out the need of Wind Energy and the various components used in energy generation and know the classifications.
4. Understand the concept of Biomass energy resources and their classification, types of biogas Plants-applications
5. Summarize the knowledge of Ocean energy, tidal energy, Geothermal energy.
6. Understand the Fuel cells principles and applications.

UNIT- I
Introduction: Renewable and Non Renewable Energy Resources, World energy status, Current energy scenario in India, Environmental aspects of energy utilization, Energy and sustainable development.

UNIT- II
Solar energy basic concepts, Flat plate and Concentrating collectors, Solar Thermal Applications-Heating, Cooling, Desalination, Drying, Cooking etc. Solar pumping, Solar photo voltaic conversion, Solar cells.

UNIT- III
Wind energy availability, Wind power plants, Wind energy conversion systems, Site characteristics, Types of wind turbines.

UNIT- IV
Energy from biomass, Biomass resources, Biomass conversion technologies - Direction combustion, Pyrolysis, Gasification, Anaerobic digestion, Biogas Plants, Bioethanol and Biodiesel production

UNIT- V
Other Renewable Sources –Ocean Energy Resources, Principle of OTEC, Tidal energy, Geothermal energy, Hydroelectric Power. Fuel cell –Principle of working -Various types -Construction and applications

Text Books:
1. Bent Sorensen, Renewable Energy, Elsevier, Academic Press, 2011
2. Bridgurater A V, Thermochemical processing of Biomass, Academic Press, 1981
3. Kishore V V N, Renewable Energy Engineering and Technology", Teri Press, New Delhi, 2012
4. Kreith F and Kreider J F, Principles of Solar Engineering, McGraw-Hill, 1978

Suggested Reading:
1. Godfrey Boyle, Renewable Energy Power for a Sustainable Future, Oxford University Press, U.K, 1996
2. Peter Gevorkian, Sustainable Energy Systems Engineering, McGraw Hill,2007

3. Sukhatme S.P., Solar Energy, Tata McGraw Hill, 1984
4. Twidell J W and Weir A, Renewable Energy Sources, EFN Spon Ltd., 1986.10.Veziroglu T.N., Alternative Energy Sources,Vol 5 and 6, McGraw-Hill, 1990
5. Anthony San Pietro, Biochemical and Photosynthetic aspects of Energy Production, Academic Press, 1980

18CH E 03 **EXPERIMENTAL AND ANALYTICAL TECHNIQUES**
(Core Elective I)

Instruction	3Hours per week
Duration of SEE	3 Hours
SEE	70Marks
CIE	30Marks
Credits	3

Course Objectives: This course will help the students to
1. Acquire knowledge about the widely used analytical Instruments
2. Essential chemical and physical principles of analytical techniques
3. Understand & select Instrument for a particular analysis with some idea of its merits, demerits and limitations
4. Practical aspects of classical chemical analysis
5. Work as a service and maintenance engineering for these Instruments

Course outcomes: At the end of the course students will be able to
1. Build basic knowledge of analytical techniques
2. Distinguish the applicability of Microscopy techniques
3. Identify the suitable spectroscopy methods
4. Select the electro-analytical techniques
5. Infer the role of different separation techniques

UNIT-I
Microscopy Techniques: scanning electron microscopy (SEM); secondary Auger microscopy (SAM); scanning probe microscopy (SPM); scanning tunneling microscopy (STM); transmission electron microscopy (TEM); upright microscope, inverted microscope, image analysis.

UNIT-II
Spectroscopy methods: FTIR, AAS, UV-VIS, UV-fluorescent, Wavelength and energy dispersive X-ray fluorescence spectroscopy (WDS and EDS); X-ray absorption spectroscopy (XANES and EXAFS); secondary ion mass spectrometry (SIMS); temperature programmed desorption (TPD); thermal desorption spectroscopy TDS), ICP-OES, XRD.

UNIT-III
Atomic absorption spectroscopy (AAS); inductively coupled plasma-atomic emission spectroscopy (ICP-AES).

UNIT-IV
Electro analytical Techniques: Voltametry; coulometry; amperometry; potentiometry; polarography; electrolytic conductivity; impedance spectroscopy, rotating disc electrode, rotating ring disc electrode.

UNIT-V
Separation Methods: Normal and reversed phase liquid chromatography (NP-& RP-LC); Gas Chromatography (GC); GC-MS; High Performance Liquid Chromatography (HPLC); Size-Exclusion Chromatography (SEC); Ion Chromatography (IC)

Text Books:
1. Wiesendanger, Scanning Probe Microscopy and Spectroscopy, Cambridge University Press, 1994
2. Frank A Settle, Handbook of instrumental techniques for analytical chemistry, Prince Hall, New Jersey, 1997

Suggested Reading:
1. D A Skoog, D M West, F. J. Holler and S. R. Couch, Fundamentals of analytical chemistry. Brooks/Cole Cengage learning, New Delhi, 2004
2. P Atkins and J de Paula, Atkins' Physical Chemistry, Oxford University Press, New Delhi, 8th Edition, 2008
3. K W Kolasinski, Surface Science: Foundations of Catalysis and Nano science, John Wiley and Sons, 2002

18CH E 04 **POLYMER SCIENCE AND TECHNOLOGY**
(Core Elective II)

Instruction	3Hours per week
Duration of SEE	3 Hours
SEE	70Marks
CIE	30Marks
Credits	3

Course objectives: This course helps the students to understand
1. The fundamental - chemical, physical and mechanical behaviour of polymers.
2. The structure-processing-property relationship of polymers.
3. The processing techniques, along with the production of polymers.
4. The synthesis, manufacture, processing and characterization of different polymers
5. The basic issues involved in polymer blends, composites and nano composites.

Course Outcomes: At the end of the course students will be able to
1. Explain the basic concepts of polymers, polymerization techniques and behaviour in polymers
2. Distinguish different types of polymerization.
3. Determine the molecular weight of polymers by different techniques
4. Familiarize with various processing techniques for polymers, rubbers and fibers
5. Summarize the manufacturing and characterization of various industrially important polymers

UNIT - I
Definitions and concepts of terms used in polymer engineering, Classification of polymers; Polymer structures, functionality; polymerization reactions – mechanism of polymerization; stereospecific polymerization, copolymerization. Polymer material structure and Properties: Deformation, flow and melt characteristics. Morphology and order in crystalline polymers. Rheology and the mechanical properties of polymers. Polymer structure and physical properties

UNIT - II
Polymerization reactors, polymerization processes, characterization of polymers, analysis of polymerization reactions, polymer degradation, Condensation polymerization, Addition polymerization, Ionic and coordination polymerization.

UNIT - III
Molecular weight and molecular weight distribution in polymers, properties of polymers – physical, chemical, mechanical and electrical properties of polymers, elementary idea on polymer rheology, polymer blends. Experimental methods for molecular weight determination: cryoscopy, ebulliometry, membrane osmometry, light scattering method, viscometry, intrinsic viscosity measurement, gel permeation chromatography. Structure and Properties: Thermal transitions, Crystallinity, Molecular weight characterization, Nuclear Magnetic Resonance (NMR) and Fourier Transform Infrared (FTIR) techniques.

UNIT – IV
Polymer processing: modeling – compression & transfer, injection & jet; casting; extrusion, calendaring, lamination, spinning & finishing. Processing methods , effect of additives used, plasticizers, colourants, heat stabilizers, antioxidants, ultraviolet absorbers, antistatic agents, flame retardants, blowing agents, fillers etc. Molding techniques for plastics, injection molding, compression molding, calendaring, blow moulding, extrusion, thermoforming, spinning methods for fibres, compounding methods for elastomers, general study of elastomer processing methods.

UNIT - V
Industrial polymers: Manufacturing processes, properties and uses of Polyethylene, Polypropylene, Polyvinylchloride, Polystyrene, Nylon, Polyethylene terephthalate. Hydrocarbon plastics and elastomers. Other carbon chain polymers. Heterochain thermoplastics. Thermosetting resins. Polymer Blends: Types, Compatibility, Thermal and Mechanical Properties. Polymer Composites: Types, Properties, Preparation, Fibre-reinforced composites, In-situ composites. Polymer Nanocomposites: Basic concepts, Processing, Characterization.

Text Books:

1. Text Book of Polymer Science, F. W. Billmeyer, John Wiley, New York, 1962
2. Polymer Science &Technology, P.Ghosh, TMC, 2001

Suggested Reading:

1. The elements of Polymer Science & Engineering, Alfred Rudin, Academic Press, 2nd Edition,1998
2. Introduction to Polymers, R. J. Young, Chapman & Hall, London, 1991

18CH E 05 **GREEN TECHNOLOGY**
(Core Elective II)

Instruction	3Hours per week
Duration of SEE	3 Hours
SEE	70Marks
CIE	30Marks
Credits	3

Course Objectives: This course helps the students to understand
1. Green systems and the environment
2. Life cycle assessment
3. Environment sustainability
4. Alternative energy technologies and efficient process systems
5. Sustainable product production and utilization

Course Outcomes: At the end of the course students will be able to
1. Describe the principles of green chemistry
2. Identify manufacturing processes for waste minimization
3. Identify technologies to reduce the level of emissions
4. Understand the importance of eco-friendly solvents
5. Apply principles of green chemistry to design greener processes

UNIT – I
Principles and Concepts of Green Chemistry: Introduction, Sustainable Development and Green Chemistry, Rearrangement Reactions, Addition Reactions, Atom Un-economic Reactions, Substitution Reactions, Elimination Reactions, Wittig Reactions, Toxicity.

UNIT – II
Waste - Production, Problems and Prevention: Introduction, Some Problems Caused by Waste, Sources of Waste from the Chemical Industry, the Cost of Waste, Waste Minimization Techniques.
Measuring and Controlling Environmental Performance: The Importance of Measurement, Introduction to Life Cycle Assessment, Green Process Metrics and Environmental Management Systems.

UNIT – III
Emerging Greener Technologies and Alternative Energy Solutions: Design for Energy Efficiency, Photochemical Reactions, Advantages and Challenges Faced by Photochemical Processes, introduction to microwave heating and sonochemistry, Electrochemical Synthesis.

UNIT – IV
Organic Solvents and Volatile Organic Compounds: Solvent-free Systems, Water as a Reaction Solvent, Water-based Coatings, Ionic Liquids as Catalysts and Solvents.

UNIT – V
Designing Greener Processes: Conventional Reactors - Batch and Continuous, Inherently Safer Design, Process Intensification.
Inherently Safer Design: safety in design, case studies of major accidents
An Integrated Approach to a Greener Chemical Industry: Society and Sustainability, Barriers and Drivers, EU White Paper on Chemicals Policy, Green Chemical Supply Strategies.

Text Books:
1. Mike Lancaster, Green Chemistry, Royal Society of Chemistry,2010
2. Paul T Anastas, John C Warner, Green Chemistry: Theory and Practice, Oxford University Press,2000

Suggested Reading:
1. Jay Warmke, Annie Warmke, Green Technology, Educational Technologies Group, 2009
2. James Clark and Duncan Macquarrie, Handbook of Green Chemistry & Technology, Blackwell Publishing, 2002

18CH E 06 **CATALYSIS**
(Core Elective II)

Instruction	3Hours per week
Duration of SEE	3 Hours
SEE	70Marks
CIE	30Marks
Credits	3

Course objectives: This course helps the students to understand
1. Different types of catalysts, their structures and synthesis processes
2. Mechanism and kinetics of heterogeneous catalysts
3. Physical and chemical catalytic properties
4. Applications of catalysis in processes
5. Catalytic reactions and reactor design

Course Outcomes: At the end of the course, student will be able to
1. Explain the basic concepts of catalysis
2. Summarize the methods of preparation and characterization of catalysts
3. Analyze the role of heat and mass transfer in the catalytic reactor design
4. Distinguish the performance of catalytic reactors
5. Identify the role of catalysts in the environmental protection
6. Explain the commercial aspects of catalytic reactors

UNIT – I
Catalysis: Introduction to Catalysis, Comparison of Catalyst Types, Basics of Heterogeneous and Homogeneous Catalysis.

UNIT – II
Basic concepts in heterogeneous catalysis: Catalyst preparation and characterization, Optimal distribution of catalyst in a pellet. Surface reactivity and kinetics of reaction on surfaces, poisoning and regeneration.

UNIT – III
Heat and mass transfer and its role in heterogeneous catalysis. Calculations of effective diffusivity and thermal conductivity of porous catalysts

UNIT – IV
Industrially important catalysts and processes such as oxidation, processing of petroleum and hydrocarbons, synthesis gas and related processes, Environmental catalysis. Zeolite catalysts, preparation, characterization and applications

UNIT – V
Commercial Catalytic Reactors (Adiabatic, fluidized bed, trickle bed, slurry etc.). Selection and design and preparation of catalysts

Text Books:
1. John Meurig Thomas, W. J. Thomas, Principles and Practice of Heterogeneous Catalysis, Wiley VCH; 2nd Edition, 2014
2. James John Carberry, Chemical and Catalytic Reaction Engineering, Dover Publications, INC,2001

Suggested Readings:
1. L K Doraiswamy, M MSharma, Heterogeneous Reactions: Fluid-fluid- solidReactions,Wiley,1984
2. B Viswanathan, S Sivasanker, and A V Ramaswamy, Catalysis: Principles and Applications ,Narosa Publishing House, 2002

18CH C 14 **CHEMICAL ENGINEERING LAB I A (MECHANICAL UNIT OPERATIONS)**

Instruction	3 Hours per week
Duration of SEE	3 Hours
SEE	35 Marks
CIE	15 Marks
Credits	1

List of Experiments

1. Verification of the laws of size reduction using Jaw crusher.
2. Verification of the laws of crushing using drop weight crusher and determination of work index.
3. Determination of laws of crushing in a pulverizer.
4. Verification of the comminution laws and critical speed of a ball mill
5. Analysis of various sizes of given material by sieve analysis and determination of cumulative and differential analysis.
6. Determination of the specific cake resistance and medium resistance in a vacuum filter or plate and frame filter press.
7. Calculation of the effectiveness of screen in horizontal and inclined position (vibrating screens)
8. Determination of separation factors of air and hydraulic classifiers.
9. Determine settling rate classification of particles using cyclone separator and to determine the efficiency
10. Determination of the froth flotation characteristics in mineral concentration

Text Books

1. W. L. McCabe, J. C. Smith and P.Harriott , Unit Operations of Chemical Engineering, 7th Ed., Tata-McGraw Hill Chemical Engineering Series, New Delhi, 2005.

18CH C 15 **CHEMICAL ENGINEERING LAB I B**
(FLUID MECHANICS AND HEAT TRANSFER)

Instruction	3 Hours per week
Duration of SEE	3 Hours
SEE	35 Marks
CIE	15 Marks
Credits	1

List of Experiments

Fluid Mechanics

1. Determination of critical velocity by Reynolds Experiments.
2. Determination of friction factor for flow through pipes with bends of different diameters and study of variation of friction factor with Reynolds number.
3. Determination of friction factor for flow of water through annulus using Fanning's and Darcy's equations.
4. Determination of characteristic curves for centrifugal pumps.
5. a) Determination of friction factor for packed beds.
   b) Determination of minimum fluidization velocity

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Heat Transfer

1. Determination of interface temperatures in composite wall under steady state conditions.
2. Determination of heat transfer coefficient in Natural convection.
3. Determination of heat transfer coefficient in forced convection.
4. Determination of emissivity and Boltzmann's constant of a sample body
5. Determination of heat transfer area in a 1-2- shell and tube heat exchangers

Text Books:

1. B.K. Dutta, 'Heat Transfer Principles and applications', PHI Learning Pvt Ltd, New Delhi,2004.
2. W. L. McCabe, J. C. Smith and P.Harriott , Unit Operations of Chemical Engineering, 7th Ed., Tata- McGraw Hill Chemical Engineering Series, New Delhi, 2005.

CHAITANYA BHARATHI INSTITUTE OF TECHNOLOGY(A)

Model Curriculum (with effect from 2019-20)

B.TECH (Chemical Engineering)

SEMESTER – VI

S.No	Course Code	Title of the Course	Scheme of Instruction			Scheme of Examination			Credits
			Hours per week			Duration of SEE in Hours	Maximum Marks		
			L	T	P/D		CIE	SEE	
	THEORY								
1	18CH C 16	Chemical Reaction Engineering II	3	-	-	3	30	70	3
2	18CH C 17	Mass Transfer II	3	-	-	3	30	70	3
3	18CH C 18	Process Control	3	-	-	3	30	70	3
4		Core Elective III	3	-	-	3	30	70	3
5		Core Elective IV	3	-	-	3	30	70	3
6		Open Elective I	3	-	-	3	30	70	3
	PRACTICALS								
7	18CH C 19	Chemical Engineering Lab IIA-CRE	-	-	3	3	15	35	1
8	18CH C 20	Chemical Engineering Lab IIB-MTO and TD	-	-	3	3	15	35	1
Total			**18**	**-**	**06**	**-**	**210**	**490**	**20**

L: Lecture T: Tutorial D: Drawing P: Practical

CIE - Continuous Internal Evaluation SEE - Semester End Examination

Core Elective III		Core Elective IV	
18CH E 07	Fluidization Engineering	18CH E 10	Sugar Technology
18CH E 08	Petrochemical Technology	18CH E 11	Pulp and Paper Technology
18CH E 09	Biochemical Engineering	18CH E 12	Food Technology

Open Elective I			
18EE O 05	Waste Management	18ME O 06	Nanomaterials and Technology
18ME O 04	Entrepreneurship	18ME O 07	Intellectual Property Rights
18CS O 09	Basics Of Artificial Intelligence		

18CH C16 **CHEMICAL REACTION ENGINEERING – II**

Instruction	3 Hours per week
Duration of SEE	3 Hours
SEE	70 Marks
CIE	30 Marks
Credits	3

Course Objectives This course helps the students to understand

1. Basic Concepts of Catalysis
2. Kinetics and Mechanistic aspects of Catalysts
3. Design and Rating of Catalytic Reactors
4. Design Aspects of Gas-Liquid Reactors

Course Outcomes At the end of the course, a student will be able to

1. Indentify and characterize solid catalysts
2. Explain the kinetics for solid catalyzed reactions
3. Interpret the kinetics of fluid and particle reactions
4. Identify regions of mass transfer control and reaction rate control in fluid-fluid reactions
5. Apply the concepts to Gas fluid and catalytic reactors

UNIT – I

Solid Catalysts - Adsorption, adsorption isotherms, surface area, void volume and solid density, pore volume distribution. Theories of heterogeneous catalysis, classification of catalysts, catalyst preparation, promoters and inhibitors

UNIT – II

Solid Catalyzed Reactions - Introduction; Development of rate expressions from L- H - H - W models for reaction $A + B \leftrightarrow R + S$ under adsorption, surface reaction and desorption controlling condition. Pore diffusion resistance combined with surface kinetics (Single cylindrical pore, first order reaction) Porous catalyst particles, mass and heat transfer within catalyst pellets. Experimental methods for finding rates.

UNIT – III

Kinetics of fluid-particle reactions: selection of a model, PCM, SCM, comparison of models with real situations. Shrinking core model for spherical particles of unchanging size: Diffusion through gas film controls, Diffusion through ash layer controls, chemical reaction controls. Rate of reaction for shrinking spherical particles.

UNIT – IV

Kinetics of fluid - fluid reactions: The rate equation for straight mass transfer of A (absorption). The general rate equation and the rate equation for reaction with mass transfer.

UNIT V

Fluid Fluid Reactors: Design of reactors for straight mass transfer and mass transfer plus not very slow reaction cases

Catalytic gas solid reactors: Design of single adiabatic fixed bed catalytic reactor

Text Books

1. Levenspiel O., “Chemical Reaction Engineering”, 3rdEdition, John Wiley & Sons, Singapore, (1999).
2. Fogler H. S., “Elements of Chemical Reaction Engineering”, 3rdEdition, Prentice Hall Inc., (1999)
3. Smith J. M., “Chemical Engineering Kinetics”, 3rdEdition, McGraw Hill, (1981).

Suggested References Books

1. Chemical and Catalytic Reaction Engineering, Carberry, J. J., Dover Books on Chemistry, 2001.
2. Chemical Reactor Analysis and Design Gilbert F. Froment, Kenneth B. Bischoff, Juray De Wilde, John Wiley & Sons, Incorporated, 2010

18CH C17 **MASS TRANSFERS- II**

Instruction	3 Hours per week
Duration of SEE	3 Hours
SEE	70 Marks
CIE	30 Marks
Credits	3

Course Objectives: This course will help the students to understand the

1. Principles of mass transfer operations to specific applications, separation and/or purification processes.
2. Theoretical/analytical aspects to design mass transfer equipments and to deal with complex problems of separations.
3. Suitable equipment required for various types of mass transfer operations.
4. Different types of Membrane process
5. Given industrial problem and apply concepts of mass transfer operations

Course outcomes: At the completion of this course, students able to

1. Understand the concept of different mass-transfer operations and their concerned equipment used in the chemical industries.
2. Interpret the importance and the role of liquid–liquid extraction and leaching in Separation Process
3. Articulate the process of adsorption and the equipment used in chemical industry
4. Calculate the enthalpies and interpret psychometric charts and design of cooling towers and drying equipment.
5. Distinguish among micro-filtration, ultra-filtration, nano-filtration, and reverse osmosis

UNIT – I: Introduction: Perspective on unified approach to operations.
Liquid – Liquid Extraction: Solubilities of ternary liquid systems. Triangular and solvent free coordinate systems. Choice of solvent. Extraction with insoluble and partially soluble systems – single stage, multistage cross-current and multistage counter-current extraction without reflux and Continuous contact extraction (packed beds). Equipment's for liquid – liquid extraction operation. Solid-Liquid Extraction:
Leaching: Preparation of solid, unsteady state operation, in-place leaching, heap leaching, percolation leaching, Shanks system, agitated vessels, percolation in closed vessels, Percolation Vs Agitation. Steady state continuous operation–equipment, methods of calculation of stage efficiency and practical equilibrium. Single stage leaching, multistage cross current leaching, multistage counter current leaching.

UNIT-II: Adsorption:
Principles of Adsorption and their applications – Types of adsorption – Adsorbents – Adsorption equilibrium – Adsorption Isotherms for vapor and dilute solutions. Single stage and multistage adsorption, Adsorption wave and breakthrough curve and fixed bed adsorption. Equipment for Adsorption operation, fixed bed adsorbers, break through . **Ion Exchange**: Principles of ion exchange, analogy between adsorption and ion exchange.

UNIT–III: Simultaneous Heat and Mass Transfer:
Humidification & Dehumidification: Vapour, gas mixtures – Humidity and relative saturation. Dew point adiabatic saturation and wet bulb temperatures – psychometric charts – Enthalpy of gas vapor mixtures. Humidification and Dehumidification techniques.
Design of Cooling Towers: Design calculations of cooling tower, Key points in the design of cooling tower step by step procedure of cooling tower.

UNIT-IV: Drying:
Equipments for Drying, moisture contents of solids – equilibrium, bound and unbound moisture. Design conditions – Rate of batch drying under constant drying conditions – Mechanism of batch drying – total time for batch drying.

UNIT-V: Membrane Process:
Types and choice of Membranes, Plate and Frame, tubular, spiral wound and hollow fiber Membrane Reactors and their relative merits, commercial, Pilot Plant and Laboratory Membrane permeators involving Dialysis, Reverse Osmosis, Nanofiltration, Ultra filtration and Micro filtration.

Text Books

1. R.E.Treybal, Mass Transfer Operations, 3rd Edition, McGraw Hill, New Delhi, 1983
2. Binay K.Dutta, Principles of Mass Transfer and Separation Processes,2nd edition, Prentice Hall of India,2007

Suggested Readings:

1. C.J. Geankoplis, Transport Processes and Unit Operations, 3rd Edition, Prentice Hall, India, 1993

18CH C 18 **PROCESS CONTROL**

Instruction	3 Hours per week
Duration of SEE	3 Hours
SEE	70 Marks
CIE	30 Marks
Credits	3

Pre-requisites: Material and Energy Balance Calculations, Chemical Reaction Engineering - I

Course Objectives: To provide a conceptual and methodological framework to
1. Mathematical modeling based on transfer function approach for single loop systems
2. Feedback control of processes - concepts, terminology, methods, and performance
3. Obtain dynamic response of open loop and closed loop systems
4. Stability analysis in transient and frequency domains
5. Controller tuning methods and advanced control strategies

Course Outcomes: At the end of the course the student will be able to:
1. Characterize and analyze the dynamic behavior of linear systems (First and Second order)
2. Build block diagrams for simple chemical processes
3. Analyze stability, speed of response, frequency response, of simple feedback control systems
4. Analyze and tune process controllers
5. Empirically identify process dynamics

UNIT – I

Introduction: Need for control and automation, Laplace transforms, solution of ODEs using Laplace transform, Response of First order system, Transfer Function, Transient response to step, impulse, sinusoidal forcing function, physical examples of first order systems, liquid level, mixing process, concept of time constant, linearization, response of first order systems in series, interacting and non-interacting systems

UNIT – II

Response of Second Order Systems: Transient response of under damped, critically damped, over damped systems to step, impulse and sinusoidal forcing functions. Transportation lag

Control Systems: Negative and Positive feedback control systems, Servo and Regulatory control problems, Development of Block diagram, Controllers and final control elements, Ideal transfer functions of P, PI, PD and PID controllers

UNIT – III

Reduction of physical control systems to block diagrams, closed loop transfer functions for servo and regulator problems. Overall Transfer functions for multi loop control systems. Transient response of simple control systems for servo and regulator problems, measurement lags. Stability of a control system by Routh's Criterion

UNIT – IV

Root Locus: concept of root locus, plotting of the root locus diagram for feedback control systems, Transient response of control system from root locus plot.

Frequency response: Bode diagrams for first order, first order system in series, second order systems and for controllers and transportation lag. Bode stability criterion, Introduction to Nyquist stability criterion

UNIT – V

Advanced Control Strategies: Cascade Control, Feed Forward Control, Ratio control, Smith-predictor, IMC, MPC, dead-time compensation

Controller Tuning and Process Identification: ISE, ITAE, IAE, Ziegler – Nicholas and Cohen-Coon tuning methods, process identification by step testing

Text Books:

1. Donald R. Coughanowr , Steven E LeBlanc, "Process Systems Analysis and Control", 3rd edition, McGraw Hill Education (India) Edition 2013

Suggested Reading:

1. George Stephanopoulos , “Chemical Process Control: An Introduction to Theory and Practice”, Prentice-Hall of India, 1984
2. Peter Harriott , “Process Control”, Tata McGraw – Hill Ltd.
3. Seborg, Edgar, Mellichamp and Doyle, “Process Dynamics and Control”, 3rd Edition, Wiley India Pvt. Ltd., 2014

18CH E07 **FLUIDIZATION ENGINEERING**
(Core Elective III)

Instruction	3L Hours per week
Duration of SEE	3 Hours
SEE	70 Marks
CIE	30 Marks
Credits	3

Course Objectives: This course helps the students to understand:

1. Basic fundamentals of fluidization and fluidized bed behavior.
2. Minimum fluidization and pressure drop across the bed.
3. Various models to analyze the behavior and mixing patterns.
4. Heat and mass transfer aspects of fluidized bed.
5. Concepts of fluidized bed combustion chamber.

Course Outcomes: At the end of the course, the students will be able to:

1. Determine the minimum fluidization velocity and optimum operating fluidization velocity.
2. Design the fluidized bed in terms of pressure drop across the bed
3. Construct the distributors, TDH, height, diameter, power consumption of compressor for air.
4. Distinguish between boiler and furnaces, methods of starting up.
5. Estimate the amount of chemicals required to control the emission like SO_2.

UNIT – I: INTRODUCTION:
Processes involving contact between solid particles and a Fluid, Packed Beds, Fluidized Beds advantages and disadvantages of fluidized beds for industrial applications. Fundamental fluidized bed behavior, Fast fluidization, circulating fluidized beds. Particles and Fluidization: Physical properties of solid particles, size and shape, size range, surface area of particles in a bed, Bed voidage, classification of particles according to Fluidization characteristics, pressure drop across packed beds, minimum fluidization velocity and its determination.

UNIT – II: TWO – PHASE THEORY OF FLUIDIZATION:
Bubbles and Fluidization Regimes, Bubble rise velocity, Bed expansion, Bubble growth and slugging, Mixing, Elutriation and Transport of solids, General mechanism of mixing of particles, mixing and segregation of particles, Terminal velocity of particles, Elutriation, transport disengaging height, solids transport. Davidson's Model, Diffusion model, Bubbling bed model ideal mixing stage model, two regime models.

UNIT – III: FLUIDIZED BED HEAT TRANSFER:
Heat Transfer in Beds of Particles, Gas -to- particle heat transfer, Bed – to- surface heat transfer, particle convection component, interphase gas connective component, Radioactive component, Estimation of Bed–to surface Heat Transfer coefficient, Heat Transfer between the Bed-Distributor, side walls, immersed tubes or components, Heat Transfer to surfaces located above the Bed, Free surface.

UNIT IV: DESIGN OF SIMPLE FLUIDIZED BEDS:
Introduction, Estimation of Bed Dimensions and Fluidizing velocity, Transport disengaging Height, Distributors, Heat removal from fluidized beds from cooling tubes in the bed, optimum size of a fluidized bed reactor. Power consumption.

UNIT – V: FLUIDIZED BED COMBUSTION:
Introduction, combustion systems for solid fuels combustors and the first law of thermodynamics, fluidized Bed combustion of solid fuels size of fluidized bed combustion system, size of inert particles in the bed, turndown efficiency of fluidized bed combustion, Equipment, combustion of fuel particles in a fluidized bed, Distinguish between boiler and furnaces, methods of starting up, circulating or fast fluidized bed combustion systems, control of emission of SOx ,CO and CO2

Text Books:
1 . J.R. Howard Adam Hilger, "Fluidized Bed Technology -Principles & Applications", IOP, Pub Ltd., NY. 1989.

Suggested Readings:
1. Diazo Kuni & Octave Levenspiel, "Fluidization Engineering", 2nd Edition, John Wiley and Sons, 2002.
2. John M. Matsen, Grace John R , "Fluidization", Springer-Verlag New York Inc., 1980.

18CH E 08 **PETROCHEMICAL TECHNOLOGIES**
(Core Elective III)

Instruction	3 Hours per week
Duration of SEE	3 Hours
SEE	70 Marks
CIE	30 Marks
Credits	3

Course objectives: This course helps the students to understand the
1. Petroleum refineries worldwide.
2. Extraction and production of oil and gas to meet energy needs.
3. Importance of refining crude oil for a wide spectrum of useful products such as petrochemicals, plastics.

Course Outcomes: At the end of the course, the students will be able to
1. Explain the composition, applications and formation theories of crude
2. Summarize the refining process of crude oil.
3. Classify Ethylene derivatives and summarize their manufacturing processes.
4. Outline Propylene and C_4 derivatives and explain their manufacture processes.
5. Classify higher paraffin derivatives and outline manufacturing processes.
6. Identify Aromatic derivatives sources and separation methods for aromatics.

UNIT−I

O**rigin and formation of petroleum**:- Organic theories, Inorganic theories and biological methods for explaining the formation of Crude oil. **Definition of refining terms :-** API Gravity, Aniline point, Octane number, Cetane number, Smoke point, Fire point, Flash point, Diesel Index, Naphtha, Types of Naphtha etc. Composition and applications of crude oil. **Petroleum Refining: -** Overall refining of crude petroleum. Production of gasoline, kerosene and lubricating oils.

UNIT− II

Rebuilding of Hydrocarbons and techniques involved: **Naphtha cracking:** Definition, types, reactions, fluidized bed cracking, description of the reactors. **Alkylation:-** Hydrofluoric acid process and sulphuric acid process **Isomerization:-** Aluminum chloride process and isomerization with platinum catalyst. **Polymerization: -** Types of polymerizations,
mechanism of polymerization, polymerization in presence of sulphuric acid, polymerizations in presence of phosphoric acid.

UNIT− III

Ethylene Derivatives: - various products with ethylene as the starting materials. **Manufacturing of the following:-** Vinyl Chloride Monomer, Perchloroethylene − pyrolysis of carbon tetra chloride, chlorination and pyrolysis method, Ethyl alcohol by direct hydration and liquid phase hydration methods, Vinyl acetate monomer, Ethylene oxide and its applications , Polyethylene, Styrene.

UNIT − IV

Propylene derivatives: - list of propylene derivatives. **Manufacturing of the following:-** Isopropyl alcohol, Acetone by catalytic dehydrogenation, Propylene oxide, Glycerine by Acrolein, allyl chloride and by isomerization of propylene oxide methods. **Derivatives of C_4 Hydrocarbons:** List of butadiene derivatives, Manufacturing of butadiene from n-butylene and by oxidative dehydrogenation. Purification of butadiene

UNIT −V

Derivative of Higher Paraffins: Manufacturing of Isoprene, olefins of C5 , C6,long chain and straight chain Olefins.

Derivatives of Aromatics: - Sources of aromatic compounds, production of aromatics. Effect of temperature, pressure and catalyst on dehydrogenation process. Separation of aromatics from Non-aromatics and separation of aromatics into individual streams

Text Books:

1. W.L.Nelson, “Petroleum refinery engineering” 4th ed., McGraw Hill company, 2013.
2. B.K.Bhasker Rao, “Modern petroleum refining process”, 5th ed., Oxford and IBH, 2008.

Suggested Reading

1. N.K.Sinha, “Petroleum Refining and Petro Chemicals”, 1st edition, Umesh publications , 2003.
2. Kirk-Othmer, “Encyclopedia of Chemical Technology”, 3rd Ed..John Wiley and sons.Inc, 2004.
3. Meyers Robert, “Hand Book of Petroleum Refining Processes”, 3rd edition McGraw Hill, 2003

18CH E 09 **BIOCHEMICAL ENGINEERING**
(Core Elective III)

Instruction	3 Hours per week
Duration of SEE	3 Hours
SEE	70 Marks
CIE	30 Marks
Credits	3

Course Objectives: This course helps the students to

1. understand the functions of living cells
2. apply the principles of Chemical Engineering to bioprocesses.
3. conduct analysis on the biological factors that are important in the design, operation, performance and/or monitoring of a biological process
4. understand the significance of microbes and enzymes
5. understand the applications of different bio processes

Course Outcomes: On successful completion of this module, students should be able to

1. Describe the basic structure and function of cells & relate cell function to products and processes useful to man
2 Explain classification, growth concepts and various types of interactions in microbes
3. Illustrate the significance of enzymes as biocatalysts and immobilized enzymes.
4. Identify and explain the basic features of bioreactors
5. Describe the principles of the various separation procedures involved in the downstream processing of products
6. Summarize the principles of Fermentation technology and products from Industrial biotechnology

UNIT – I Introduction to Biochemical Engineering, Molecular Biology& Bio Chemistry
Biochemical Engineering Principles, Biophysics and cell doctrine: Atomic Theory and Cell Theory, Important cell types, structure and functions of a typical cell and their components, Transport across cell membranes: Passive and facilitated diffusion, Active transport Structure and functions of Bio Molecules: Carbohydrates, lipids, Nucleotides to Nucleic Acids – RNA and DNA, Amino acids to Proteins - the building blocks of biochemical life Biosynthesis and Metabolic Pathways: Biosynthesis of Small and Macro Molecules Introduction of metabolic pathways and end products of glucose metabolism.

UNIT – II Introductory Microbiology
Introduction to Microbiology: Classification and Industrial uses of Microorganisms Growth and Reproduction of Microbes: Growth cycle phases for batch cultivation. Monod's growth kinetics – Growth Rate dependant classification of Microorganisms.
Microbial Genetics: Recombinant DNA technology and mutant populations. Multiple Interacting Microbial populations: Neutralism, Mutualism, Commensalism, Amesanalism, Predatism and Parasitism

UNIT – III Enzyme Technology
Enzymology: Enzymes as Biocatalysts - The enzyme substrate complex and enzyme action and Classification of Enzymes based on Functions.
Kinetics of Enzyme Catalyzed Reactions: Simple enzyme kinetics with one and two substrates. Determination of rate constants, substrate activation and inhibition, modulation and regulation of enzyme activity / effect of PH and temp on enzyme activity.
Immobilized Enzyme Technology: Types of Enzyme immobilization, Immobilized enzymes in industrial processes,
Cofactors, Apo-enzymes and Coenzymes utilization and regeneration

UNIT – IV Bioreactors and Down Stream Techniques - Introduction
Design and Analysis of Biological Reactors: Batch and Continuous Stirred Tank Reactors, Enzyme reactors Ideal
Reactors for kinetic measurements: The ideal batch reactor / The ideal continuous flow stirred tank reactor - Alternate bio-reactor configurations
Separation Processes: Filtration, Centrifugation, Adsorption, Reverse osmosis, Dialysis, Electrophoresis, Sedimentation and Extraction Purification Processes: Precipitation, Crystallization, and Chromatography

UNIT – V Bioprocess Technology

Fermentation Technology: Types of Fermentation, Medium formulation and Culture Propagation, Environmental Biotechnology: Effluent treatment.

Industrial Biotechnology: Commercial enzymes, Antibiotics and single cell protein

Text Books:

1. James, E Bailey and David F Ollis, "Biochemical Engineering fundamentals", 2nd Edition, McGraw-Hill Internal Edition.1986
2. Prof. Shigeo Katoh, Prof. Fumitake Yoshida, "Biochemical Engineering: A Textbook for Engineers, Chemists and Biologists", First Edition, Wiley-VCH Verlag GmbH & Co. 2010

Suggested Reading:

1. Michael L Shuler and Fikret Kargi, "Bioprocess Engineering: Basic Concepts". Second Edition Prentice Hall, 2002

18CH E10 **SUGAR TECHNOLOGY**
(Core Elective IV)

Instruction	3L Hours per week
Duration of SEE	3 Hours
SEE	70 Marks
CIE	30 Marks
Credits	3

Course Objectives: This course helps the students to understand**:**

1. The performance measures of different types of unit operations in sugar processing.
2. Applications, advantages and limitations of the processing procedure.
3. The competence and optimization of advanced technology in sugar processing.
4. The possible by-products of any sugar industry and production of saleable derivatives.

Course Outcomes: At the end of the course, the student able to:

1. Apply Principles and skills of work in sugar cane milling, processing and refining in practical settings.
2. Determine the composition of different types of sugars by volumetric and gravimetric methods.
3. Explain the unit operations for effective processing of cane juice, Batch and continuous methods
4. Identify the concepts of quality assurance and control in industry as per Indian regulations and practices.
5. Summarize the methods to reclaim by-products.

UNIT - I

Importance of sugar industry. Different raw materials for sugar manufacturing, composition of raw materials, history, origin and distribution of sugarcane, production and productivity of sugarcane in India. Indian sugar industry on global screen. Manufacturing processes of raw sugar and crystalline white sugar. Reducing sugars - composition, volumetric and gravimetric determination methods.

UNIT - II

Conveying of raw materials - cane carrier and feeding table working principles. Cane preparation – objective, sieving, preparation index, cane knives, crushing and shredding applications. Extraction of cane juice by milling operation - basic concept of roller mills, working principles, conditions for good milling operation, milling efficiency, maceration and imbibitions – importance, effect, method, objective and efficiency. Cane juice clarification – simple, compound and neutral defaction procedures. Sulphitation and carbonation - batch and continuous methods. Single and double carbonation process, De-Hans‟ process, comparison of different clarification modern techniques.

UNIT - III

Juice heaters - construction and working principles. Juice filtration - plate and frame filter presses, RVDF, types of filter cake washing. Evaporation- multiple effect evaporators - construction and operation. Steam economy and capacity. Vacuum pan boiling - construction, types of pans, speed of circulation, heating surface to volume ratio, pan boiling techniques, different boiling schemes.

UNIT - IV

Crystallization – nucleation, graining methods, advantages and disadvantages of graining. Theory of crystallization, crystallization zone, crystal growth. centrifuge –construction & working, factors influences on time of curing. Advantages and disadvantages of batch / continuous centrifugal machine. Separation of molasses-different molasses conditioning methods, precautions during molasses conditioning. Sugar drying - various aspects regarding drying and cooling, rotary dryer. Packing of sugar -types of sugar grader, dilution indicator, quality and safety factors, location and stalking of sugar bags.

UNIT - V

Sugar by-products: bagasse, press mud and molasses- their composition and applications. Production of bio-gas, fiber board, furfural filter mud, extraction of cane wax, manure, industrial alcohol and rectified spirit. Sugar scales and normal weight.

Text Books:

1. Meade and Chen, “Hand of book of cane sugar”, 11th Ed, Wiley Inter science, New York, 2001.
2. James C.P Chen, “Cane Sugar Hand book”, 12th Ed, Elsevier Pub. Co., New York, 1993.

Suggested Readings:

1. R B L Mathur, Hand Book of Cane Sugar Technology", 2nd Ed, Oxford & IBH, 1978. 2. 2.John H. Payne, "Unit operation in cane sugar production", Sugar series book 4, Elsevier Pub. Co., New York, 1982.

18CH E11 **PULP AND PAPER TECHNOLOGY**
(Core Elective IV)

Instruction	3L Hours per week
Duration of SEE	3 Hours
SEE	70 Marks
CIE	30 Marks
Credits	3

Course Objectives: This course will help the students to understand the

1. Basic concepts of Pulp and Paper making processes.
2. Overview of pulping process.
3. Details of physical and chemical characteristics of fibrous raw materials and black liquor.
4. Various types of cooking and bleaching methodologies.
5. Recovery of energy and chemicals used in pulping processes with due techno-economic and environmental considerations.

Course Outcomes: At the completion of this course, the students able to:

1. Design the operation, maintenance and safety aspects for paper making.
2. Identify grade paper and boards based on different testing methods.
3. Select appropriate bleaching technique for required paper quality.
4. Differentiate the important wood and fibre properties that affect paper quality.
5. Identify, formulate and solve design problems pertaining to pulp digesters.

UNIT – I: Introduction
Importance of Paper, Definitions of Pulps
Wood Parts & Types: Ultra structure of Cell Wall, Wood cell types, Early & Latewood, Softwoods, Hard woods & Non-woods. Comparison of different raw materials.
Distribution of Wood Constituents – Cellulose, Hemi-cellulose, Lignin, Extractives and Inorganic components.

UNIT – II: Overview of pulping process
Mechanical Pulping: Pressurized ground pulping, Refiner Pulping, Chemo (thermo) mechanical pulping processes.
Kraft Pulping: Description of Kraft Cooking Process, Kraft recovery, Composition & Analysis of white liquor, Chemical reactions & process variables. Pulp yield, End uses of kraft pulps.

UNIT – III: Pulp and black liquor characterization
Pulp testing methods - Kappa number, water retention value, CED viscosity, drainability, beater evaluation, zero span tensile strength.
Black liquor characterization - Chemical properties, viscosity and rheological behavior at different concentrations, thermal properties, calorific value, thermal conductivity, specific heat, black liquor oxidation, desilication and concentration of black liquor.

UNIT IV: Bleaching operations
Objectives of bleaching – Elemental chlorine free and total chlorine free bleaching; Bleachability and its measurement, bleaching reactions, reaction kinetics and operating variables for different bleaching agents like ClO_2, O_2, O_3, hypochlorite, H_2O_2.
Stages of bleaching – Oxygen delignification, Chlorination, Extraction, Hypochlorite bleaching, Ozone bleaching, Peroxide bleaching, Operating variables for different bleaching stages; ECF and TCF bleaching systems for chemical pulps; bleaching systems for mechanical and high yield pulps.

UNIT – V: Paper Making and its Properties
Paper Testing Methods – Flow sheet of complete pulp and paper making process, Strength properties, Surface properties, Optical properties & Absorption properties. Different grades of paper, boards & newsprint specifications; BIS and ISO standards of paper. Paper properties dependence on paper making processes, Calibration of instruments. Paper recycling process, Effluent treatment processes with environmental considerations.

Text Books:

1. Kenneth W. Britt, "Handbook of Pulp & Paper Technology", 2nd Edition, Reinhold Publishing Corporation, 2004.
2. G. A Smook., "Handbook for Pulp & Paper Technologists", 3rd Edition, Angus Wilde Publications, 2003.

Suggested Readings:

1 .Hakan Karlsson, "Fiber Guide-Fiber analysis and process applications in the pulp & paper industry", Ab Lorentzen & Wetre, 1st Edition, 2006.
2. EIRI Board ., "Handbook of Pulp & Paper, Paper board and Paper based Technology", Engineers India Research Institute, 2nd Edition, 2015 .

18CH E 12 **FOOD TECHNOLOGY**
(Core Elective IV)

Instruction	3 Hours per week
Duration of SEE	3 Hours
SEE	70 Marks
CIE	30 Marks
Credits	3

Course objectives: This course helps the students to understand the

1. Basic food preparation techniques. Food quality.
2. Physical, chemical, and/or microbiological changes in food and mechanical manipulation.
3. Learn fundamentals of modifying food to meet current nutrition recommendations
4. Learn to find credible sources of information re. food science and nutrition.
5. Food processing Applications and Packaging

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

1. Explain techniques in food processing
2. Design process equipment to achieve the desired quality of food.
3. Develop novel food processes that have a minimal effect on food quality
4. Select control strategies to maintain food quality.
5. Apply the scientific method to food science problems.

UNIT – I

Introduction: General aspects of food industry, World food demand and Indian scenario, Constituents of food, Quality and nutritive aspects, Product and Process development, engineering challenges in the Food Processing Industry.

UNIT – II

Basic principles: Properties of foods and processing theory, Heat transfer, Effect of heat on micro-organisms, Basic Food Biochemistry and Microbiology: Food Constituents; Food fortification, Water activity, Effects of processing on sensory characteristics of foods, Effects of processing on nutritional properties, Food safety, good manufacturing practice and quality Process Control in Food Processing.

UNIT – III

Ambient Temperature Processing: Raw material preparation, Size reduction, Mixing and forming, Separation and concentration of food components, Centrifugation, Membrane concentration, Fermentation and enzyme technology, Irradiation, Effect on micro-organisms, Processing using electric fields, high hydrostatic pressure, light or ultrasound.

UNIT – IV

Heat processing using steam, water and air: Blanching, Pasteurization, Heat sterilization, Evaporation and distillation, Extrusion, Dehydration, Baking and roasting, Heat processing by direct and radiated energy: Dielectric heating, Ohmic heating, Infrared heating, Gamma irradiation.

UNIT – V

Post Processing Applications Packaging: Coating or enrobing, Theory and Types of packaging materials, Printing, Interactions between packaging and foods, Environmental considerations.

Text Books:

1. Fellows P., Food Processing Technology: Principles and Practice, Wood head Publishing, 4th Edition, 2016.
2. Toledo R, Fundamentals of Food Process Engineering, Springer, 3rd Edition, 2010.

Suggested Readings:

1. Singh R.P. & Heldman D.R., Introduction to Food Engineering, Academic Press, 3rd Edition, 2001.

18EEO 05 **WASTE MANAGEMENT**
(Open Elective I)

Instruction	3 Hours per week
Duration of SEE	3 Hours
SEE	70 Marks
CIE	30 Marks
Credits	3

Course Objectives:
1. To Imbibe the concept of effective utilization of any scrap
2. To become familiar with the processes of all disciplines of engineering.
3. To learn the technique of connectivity from waste to utility.

Course Outcomes:
1. Understand the various processes involved in allied disciplines of engineering
2. Infer the regulations of governance in managing the waste
3. Distinguish the nature of waste materials concerned to the particular branch of engineering
4. Explore the ways and means of disposal of waste material
5. Identify the remedies for the disposal of a selected hazardous waste material

UNIT-I
Introduction to waste management: Relevant Regulations Municipal solid waste (management and handling) rules; hazardous waste (management and handling) rules; biomedical waste handling rules; fly ash rules; recycled plastics usage rules; batteries (management and handling) rules. Municipal Solid Waste Management – Fundamentals Sources; composition; generation rates; collection of waste; separation, transfer and transport of waste; treatment and disposal options.

UNIT-II
Hazardous Waste Management : Fundamentals Characterization of waste; compatibility and flammability of chemicals; fate and transport of chemicals; health effects, Radioactive Waste Management – Fundamentals Sources, measures and health effects; nuclear power plants and fuel production; waste generation from nuclear power plants; disposal options.

UNI-III
Environmental Risk Assessment: Defining risk and environmental risk; methods of risk assessment; case studies, Physicochemical Treatment of Solid and Hazardous Waste Chemical treatment processes for MSW (combustion, stabilization and solidification of hazardous wastes); physicochemical processes for hazardous wastes (soil vapor extraction, air stripping, chemical oxidation); ground water contamination and remediation

UNIT-IV
Biological Treatment: Solid and Hazardous Waste Composting; bioreactors; anaerobic decomposition of solid waste; principles of biodegradation of toxic waste; inhibition; co-metabolism; oxidative and reductive processes; slurry phase bioreactor; in-situ remediation.

UNIT-V
Landfill design aspects: Landfill design for solid and hazardous wastes; leachate collection and removal; landfill covers; incineration

Text Books:
1. John Pichtel Waste Management Practices CRC Press, Taylor and Francis Group 2005.
2. LaGrega, M.D.Buckingham,P.L. and Evans, J.C. Hazardous Waste Management, McGraw Hill International Editions, New York, 1994
3. Richard J. Watts, Hazardous Wastes - Sources, Pathways, Receptors John Wiley and Sons, New York, 1997

Suggested Reading:
1. Basics of Solid and Hazardous Waste Mgmt. Tech. by Kanti L.Shah 1999, Prentice Hall.
2. Solid and Hazardous Waste Management 2007 by S.C.Bhatia Atlantic Publishers & Dist.

18ME O04 **ENTREPRENEURSHIP**

(Open Elective I)

Instruction	3 Hours per week
Duration of SEE	3 Hours
SEE	70 Marks
CIE	30 Marks
Credits	3

Objectives:

1. Concept and procedure of idea generation.
2. The nature of industry and related opportunities and challenges.
3. Elements of business plan and its procedure.
4. Project management and its techniques.
5. Behavioral issues and Time management.

Outcomes: At the end of the course, the students are able to

1. Understand the concept and essence of entrepreneurship. (BL-2)
2. Identify business opportunities and nature of enterprise. (BL-3)
3. Analyze the feasibility of new business plan. (BL-4)
4. Apply project management techniques like PERT and CPM for effective planning and execution of Projects (BL-3)
5. Use behavioral, leadership and time management aspects in entrepreneurial journey (BL-3)

UNIT-I

Entrepreneurship: Definition, functions of entrepreneurship, qualities of entrepreneurs, identification and characteristics of entrepreneurs, entrepreneur vs. intrapreneur, first generation entrepreneurs, women entrepreneurs, conception and evaluation of ideas and their sources.

UNIT-II

Indian industrial environment: Competence, opportunities and challenges, entrepreneurship and economic growth, small scale industry in India, objectives, linkage among small, medium and heavy industries, types of enterprises, corporate social responsibility.

UNIT-III

Business plan: Introduction, elements of business plan and its salient features, business model canvas, technical analysis, profitability and financial analysis, marketing analysis, feasibility studies, executive summary, selection of technology and collaborative interactions.

UNIT-IV

Project management: During construction phase, project organization, project planning and control using CPM, PERT techniques, human aspects of project management, assessment of tax burden.

UNIT-V

Behavioral aspects of entrepreneurs: Personality, determinants, attributes and models, leadership concepts and models, values and attitudes, motivation aspects, time management: approaches of time management, their strengths and weaknesses. time management matrix and the urgency addiction .

Text Books:

1. Vasant Desai, "Dynamics of Entrepreneurial Development and Management", Himalaya Publishing House, 1997.
2. Prasanna Chandra, "Project-Planning, Analysis, Selection, Implementation and Review", Tata Mcgraw-Hill Publishing Company Ltd.1995.
3. S.S. Khanka, "Entrepreneurial Development", S. Chand & Co. Pvt. Ltd., New Delhi,2015.

Suggested Reading:

1. Robert D. Hisrich, Michael P. Peters, "Entrepreneurship", 5/e, Tata Me Graw Hill Publishing Company Ltd., 2005.
2. Stephen R. Covey and A. Roger Merrill, "First Things First", Simon and Schuster Publication,1994.

18ME O06 **NANO MATERIALS AND TECHNOLOGY**
(Open Elective I)

Instruction	3 Hours per week
Duration of SEE	3 Hours
SEE	70 Marks
CIE	30 Marks
Credits	3

Objectives:
1. Nanotechnology approach and challenges.
2. Materials and characterization procedures.
3. Zero and one dimensional nanostructures.
4. Various fabrication techniques.
5. Special nano materials and nano biomaterials.

Outcomes: At the end of the course, the students are able to
1. Understand the basic concepts, developments and challenges in nanotechnology. (BL-2)
2. Describe the methods of evaluating magnetic and electronic properties, microstructure by SPM and atomic force microscopy. (BL-2)
3. Apply heterogeneous methods and characterization techniques of zero & one dimensional nanostructure (BL-3)
4. Evaluate various nano material fabrication techniques. (BL-5)
5. Analyze nano materials and nano biomaterials for obtaining solutions to societal problems. (BL-4)

UNIT - I
Introduction: Nanoscale, properties at nanoscale, advantages and disadvantages, importance of nanotechnology, bottom-up and top-down approaches, challenges in nanotechnology.

UNIT - II
Materials of Nanotechnology: Introduction, Si-based materials, Ge-based materials, ferroelectric materials, polymer materials, GaAs &InP (HI-V) group materials, nano tribology and materials, characterization using scanning Probe microscope, AFM.

UNIT - III
Nano structures: Zero dimensional nanostructure, synthesis procedure by heterogeneous method, characterization techniques, properties and applications of nano particles
One dimensional nanostructures: Synthesis procedure, characterization procedure and principles involved, properties and applications of nanowires .

UNIT - IV
Nano fabrication: Introduction, basic fabrication techniques by lithography and doping, MEMS fabrication techniques, nano fabrication techniques by E-beam, nano-imprint fabrication, epitaxy and strain engineering.

UNIT - V
Special nano materials: Introduction, synthesis procedure by metal-polymer, characterization procedures, applications.
Nano biomaterials: Introduction, biocompatibility, anti-bacterial activity, applications.

Text Books:
1. Dieter Vollath, “Nanomaterials: An introduction to Synthesis, properties and applications”, Wiley,2013.
2. GuozhongCao,“NanostructuresandNanoMaterials,Synthesispropertiesandapplications”,ImperialCollege Press,2004.
3. Carl C Koch, “Nano materials Synthesis, Properties and applications”, Jaico Publishing House,2008.

Suggested Reading:
1. Willia Tllsey Atkinson, “Nano Technology”, Jaico Publishing House,2009.
2. George W. Hanson, “Fundamentals of Nanoelectronics”, Pearson Education,2009.

18ME O07 **INTELLECTUAL PROPERTY RIGHTS**
(Open Elective I)

Instruction	3 Hours per week
Duration of SEE	3 Hours
SEE	70 Marks
CIE	30 Marks
Credits	3

Objectives:

1. Fundamental aspects of IP.
2. Salient features of IPR acts.
3. The methods of registrations of Intellectual property.
4. Awareness for innovation and its importance of protection.
5. The changes in IPR culture and techno-business aspects of IPR.

Outcomes: At the end of the course, the students are able to

1. Understand the evolution of IP, working of organization's at global level to protect and promote IP (BL-2)
2. Familiarize with the patent filing process at national and international level. (BL-2)
3. Draw the logical conclusion of research, innovation and patent filing. (BL-3)
4. Compare different kinds of IP and their patenting system. (BL-4)
5. Understand the techno-legal-business angle of IP, infringement and enforcement mechanisms for protection. (BL2)

UNIT I

Introduction: Definition of intellectual property, the need for intellectual property rights (IPR), kinds of intellectual property rights, IPR in India – genesis and development, IPR abroad, importance of WTO, TRIPS agreement, patent cooperation treaty, Berne and universal copyright conventions.

UNIT-II

Patents: Definition of patent, commercial significance , term of patent, patentable subject- matter, rights and obligations of patentee, searching of existing patents, drafting of patent, specification of patent, filing of a patent, the different layers of the patent system (national, regional and international options), compulsory licensing and licenses of rights, revocation of patents, differences between utility model and patent.

UNIT-III

Industrial designs: Definition of designs, registration of design, rights and duties of proprietor of design, piracy of registered design.

Trademarks: Meaning of trademarks, purpose of protecting trademarks, registration of trademarks, passing off, assignment and licensing of trademarks, infringement of trademarks.

Geographical indications: Definition, differences between GI and trademarks.

UNIT-IV

Copy right: Nature and scope of copy right, term of copyright, subject matter of copyright, rights conferred by copyright ,publication, broad casting, telecasting, computer program, database protection, assignment and transmission of copyright, infringement of copy right trade secrets and know-how agreement.

UNIT-V

Enforcement of intellectual property rights: Infringement of intellectual property rights, enforcement measures, emerging issues in intellectual property protection, case studies of patents and IP Protection.

Unfair competition: What is unfair competition, relationship between unfair competition and intellectual property law

Text Books:

1. Ajit Parulekar and Sarita D"Souza, "Indian Patents Law-Legal& Business Implications ",Macmillan India Ltd., 2006.
2. B.L.Wadehra, "Law relating to Patents, Trade Marks, Copyright, Designs &Geographical Indications", Universal law Publishing Pvt Ltd., India, 2000.
3. P. Narayanan, "Law of Copyright and Industrial Designs"; Eastern law House, New Delhi,2010.

Suggested readings:

1. Cronish W.R, “Intellectual Property Patents, Copyright, Trade Marks and Allied rights”, Sweet Maxwell,1993.
2. P. Narayanan, “Intellectual Property Law” Eastern Law Edn., 1997.

18CSO 09 **BASICS OF ARTIFICIAL INTELLIGENCE**
(Open Elective I)

Instruction	3 Hours per week
Duration of SEE	3 Hours
SEE	70 Marks
CIE	30 Marks
Credits	3

Pre-requisites: Basic Mathematics.

Course Objectives: The main objectives of this course are:
1. To Provide fundamental concepts in Artificial Intelligence.
2. Discuss the various paradigms involved in solving an AI problems which involve perception, reasoning and learning
3. Apply the AI concepts to build an expert system to solve the real-world problems.

Course Outcomes: On Successful completion of this course, student will be able to
1. Identify various search strategies to solve problems.
2. Compare and contrast knowledge representation schemes.
3. Apply Bayesian Networks and Dempster Shafer theory for reasoning.
4. Explain the role of agents and interaction with the environment.
5. Determine different learning paradigms.
6. Explain robotic architectures and expert systems.

UNIT - I
Introduction: Definition, history, applications. Problem Solving: AI problems, AI Technique, Defining problem as a State-Space Search, Problem Characteristics. Heuristic Search Techniques: Generate–and–test, Hill Climbing, Constraint Satisfaction.

UNIT - II
Knowledge Representation (Logic): Representing facts in logic, proposition logic, predicate logic, resolution and unification. Knowledge Representation (Structured): Declarative representation, Semantic nets, procedural representation, frames.

UNIT - III
Reasoning: Probability and Bayes theorem, Certainty factors and Rule based systems, Bayesian Networks, Dempster-Shafer Theory. Planning: Components, goal stack planning, nonlinear planning, hierarchical planning.

UNIT - IV
Learning: Introduction, Rote learning, learning by taking advice, learning in problem solving and learning from examples: Decision tree. Intelligent Agents: Classification, Working of an agent, single agent and multi agent systems, multi agent application.

UNIT - V
Expert System: Representing and Using Domain Knowledge, Expert systems shells, Explanation, Knowledge Acquisition. Perception and Action: Real Time Search, Vision, Speech Recognition, ACTION: Navigation, Manipulation, Robot architectures.

Text Books:
1. Elaine Rich, Kevin Night, Shivashankar B Nair, “Artificial Intelligence”, 3rd Edition, 2008
2. Russell Norvig, “Artificial Intelligence-Modern Approach”, 3rd edition, 2010.

Suggested Reading:
1. Saroj Kaushik, “Artificial Intelligence”, Cengage Learning India, 2012.
2. Nelson M. Mattos, “An Approach to Knowledge Base Management”, Springer Berlin Heidelberg, 1991.

Online Resources:
1. http://nptel.ac.in/courses/106106126/
2. http://nptel.ac.in/courses/106105077/

18CH C 19 **CHEMICAL ENGINEERING LAB II A**
(CHEMICAL REACTION ENGINEERING)

Instruction	3 Hours per week
Duration of SEE	3 Hours
SEE	35 Marks
CIE	15 Marks
Credits	1

List of Experiments

Chemical Reaction Engineering

1. Studies in Batch Reactor: To find the Arrhenius form of temperature dependency of reaction
2. Studies in Mixed Flow Reactor (CSTR) : To find kinetics from reactor performance of CSTR
3. Studies in Tubular Reactor: To determine the rate constant and to verify the order of reaction
4. Mass Transfer with Chemical Reaction: (Liquid – Liquid Reaction System) To find out the mass transfer coefficient in a stirred cell: With chemical reaction and without chemical reaction
5. Mass Transfer with Chemical Reaction: (solid – Liquid Reaction System) To find the mass transfer coefficient without chemical reaction and with chemical reaction.
6. R.T D Studies in Packed bed reactor: To determine the axial mixing (axial dispersion) in the packed column.
7. R T D Studies in Tubular Column To determine the variance of residence time distribution and the dispersion number in a tubular column.
8. Studies in Batch Reactor: With Equimolar Feed (M = 1) : To determine the rate constant and to verify the order of reaction by differential & integral methods of analysis.
9. Studies in Batch Adiabatic Reactor: to determine the kinetics of an exothermic reaction from the Temperature of the reaction system.
10. Studies in Mixed Flow Reactors in series: To compare the actual & ideal performances of a Reaction system.
11. Studies in Packed bed: To determine the rate constant and to verify the order of reaction from performance of the reactor.

Text Book

1. Octave Levenspiel, Chemical reaction Engineering, 3rd Ed, Wiley India Pvt.Ltd, New Delhi, 2006

18CH C 20 **CHEMIAL ENGINEERING LAB II B**
(MASS TRANSFER OPERATIONS & THERMODYNAMICS)

Instruction	3 Hours per week
Duration of SEE	3 Hours
SEE	35 Marks
CIE	15 Marks
Credits	1

List of Experiments

Mass Transfer Operations

1. Estimation of diffusivity coefficient for the gaseous system (CCl4 - Air)
2. Estimation of the mass - transfer coefficient k_G for Air- Water system and plotting the variation of k_G with Reynolds‟s number.
3. Determination of vapour - liquid equilibrium data for the given system.
4. Verification of the Rayleigh`s equation for the system of methanol and water
5. Determination of the capacity coefficient of the packed column under total reflux conditions and calculation of height equivalent to theoretical plate.
6. Developing the drying curve by using tray drier and estimation and composition of time required for drying the given solid.

Thermodynamics

1. Determine the PVT behaviour of pure fluids by using Equation of state Liquid- Liquid Equilibrium Equipment
2. Calculate the property change of mixing
3. To determine the relationship between vapour and liquid at different temperatures
4. To determine the solubility characteristics of given solution at different temperatures

Text Books

1. R.E.Treybal, Mass Transfer Operations, 3rd Edition, McGraw Hill, New Delhi, 1983
2. Introduction to Chemical Engineering Thermodynamics (in SI units) by J M Smith and H C Van Ness and M M Abbott, 7th edition, Mc-Graw Hill International Edition, 2005