BACHELOR OF TECHNOLOGY (CHEMICAL ENGINEERING)

3rd Semester

S.No.	Course Name	L	T	P	Credits
PE251	Engineering Materials and Metallurgy	3	0	2	4
CH201	Chemical Engineering Process Calculations	3	1	0	4
CH203	Transport Phenomena	3	1	0	4
CH205	Chemical Engineering Thermodynamics	3	0	2	4
CH207	Engineering Design and Analysis (Process Equipment Design)	3	0	2	4
FECXXX	Foundation Elective	2	0	0	2

4th Semester

S.No.	Course Name	L	T	P	Credits
EE272	Instrumentation and Process Control	3	0	2	4
CH202	Fluid Mechanics	3	0	2	4
CH204	Chemical Reaction Engineering-1	3	0	2	4
CH206	Mechanical Operations	3	0	2	4
CH208	Heat Transfer	3	0	2	4
FECXXX	Foundation Elective	2	0	0	2

5th Semester

S.No.	Course Name	L	T	P	Credits
CH301	Polymeric Materials	3	0	2	4
CH303	Mass Transfer-1	3	0	2	4
CH3XX	Departmental Elective/General Elective-1	3/0	1/0	8/2/0	4
CH3XX	Departmental Elective/General Elective-2	3/0	1/0	8/2/0	4
CH3XX	Departmental Elective/General Elective-3	3/0	1/0	8/2/0	4
MG301	Fundamentals of Management	3	0	0	3

6th Semester

S.No.	Course Name	L	T	P	Credits
CH302	Chemical Reaction Engineering-II	3	0	2	4
CH304	Mass Transfer-II	3	0	2	4
CH306	Chemical Process Technology	3	0	2	4
CH3XX	Departmental Elective/General Elective-4	3/0	1/0	8/2/0	4
CH3XX	Departmental Elective/General Elective-5	3/0	1/0	8/2/0	4

HU302	Engineering Economics	3	0	0	3

7th Semester

S.No.	Course Name	L	T	P	Credits
CH401	B.Tech Project-1	-	-	-	4
CH403	Training and Seminar	-	-	-	2
CH4XX	Departmental Elective/ General Elective-6	3/0	1/0	8/2/0	4
CH4XX	Departmental Elective/General Elective-7	3/0	1/0	8/2/0	4
CH4XX	Departmental Elective/General Elective-8	3/0	1/0	8/2/0	4
CH4XX	Departmental Elective/General Elective-9	3/0	1/0	8/2/0	4

8th Semester

S.No.	Course Name	L	T	P	Credits
CH402	B.Tech Project-II	-	-	-	8
CH4XX	Departmental Elective/General Elective -10	3/0	1/0	8/2/0	4
CH4XX	Departmental Elective/General Elective-11	3/0	1/0	8/2/0	4
CH4XX	Departmental Elective/General Elective-12	3/0	1/0	8/2/0	4

List of Departmental Electives Courses

S. No.	Subject Code	Subject	Elective No.
1.	CH305	Characterization of Materials	DEC/GEC–1,2,3
2.	CH307	Petroleum Refining Engineering	
3.	CH309	Chemical Process and Simulations	
4.	CH311	Rheology	
5.	CH313	Corrosion Engineering	
6.	CH315	Plastic Technology	
7.	CH317	Resin Technology	
8.	CH319	Rubber Technology	
9.	CH321	Numerical Methods in Chemical Engineering	

10	CH323	Biomaterials	
11.	CH308	Food Technology	DEC/GEC – 4,5
12	CH310	Paint Technology	
13	CH312	Polymer Processing Techniques	
14	CH314	Fertilizer Technology	
15	CH316	Coatings and Adhesives	
16	CH318	Petrochemical Engineering	
17	CH320	Packaging Technology	
18	CH322	Tyre Technology	
19	CH324	Heat Exchangers	
20.	CH405	Fiber Technology	DEC/GEC – 6,7,8,9
21.	CH407	Polymer Blends and Composites	
22.	CH409	Plant Engineering and Process Economics	
23.	CH411	Advanced Mass Transfer Operations	
24.	CH413	Bio-Chemical Engineering	
25	CH415	Rocket Propulsion and Explosives	
26	CH417	Polymer Waste Management	
27	CH419	Computational Fluid Dynamics	
28	CH421	Polymer Reaction Engineering	
29	CH423	Optimization Techniques	
30	CH425	Application of Polymers in Biomedical	
31	CH427	Combustion Engineering	
32	CH429	Energy Resources	
33	CH431	Membrane Technology	
34	CH404	Fuel Cell Technology	

35	CH406	Catalysis	DEC/GEC–10,11,12
36	CH408	Specialty Polymers	
37	CH410	Process Engineering and Design	
38	CH412	Thermoplastic Elastomers	
39	CH414	Non-woven Technology	
40	CH416	Industrial Waste Management	
41	CH418	Application of Nanotechnology in Polymers	
42	CH420	Inorganic Polymers	
43	CH422	Pharmaceutical Technology	
44	CH424	Safety & Hazards in Chemical Industries	
45	CH426	Biofuel Engineering	
46	CH428	Energy Conservation and Recycling	

1. Minor in Polymer Technology

A] For B.Tech. Chemical Engineering

Student must complete 20 Additional Credits from the following pool of subjects to get Minor in Polymer Technology

Subject Code	**Name of Subject**
CH311	Rheology
CH315	Plastic Technology
CH317	Resin Technology
CH319	Rubber Technology
CH310	Paint Technology
CH312	Polymer Processing Techniques
CH316	Coatings and Adhesives
CH320	Packaging Technology
CH322	Tyre Technology
CH405	Fiber Technology
CH407	Polymer Blends and Composites
CH417	Polymer Waste Management
CH425	Application of Polymers in Biomedical
CH408	Specialty Polymers
CH412	Thermoplastic Elastomers
CH414	Non-woven Technology

CH418	Application of Nanotechnology in Polymers
CH420	Inorganic Polymers

B] For Other Disciplines

Student must complete 24 Additional Credits from the following pool of subjects to get minor specialization certificate in Polymer Technology. Core is compulsory.

Core		**Electives**	
Subject Code	**Name of Subject**	**Subject Code**	**Name of Subject**
CH301	Polymer Materials	CH311	Rheology
		CH315	Plastic Technology
		CH317	Resin Technology
		CH319	Rubber Technology
		CH310	Paint Technology
		CH312	Polymer Processing Techniques
		CH316	Coatings and Adhesives
		CH320	Packaging Technology
		CH322	Tyre Technology
		CH405	Fiber Technology
		CH407	Polymer Blends and Composites
		CH417	Polymer Waste Management
		CH425	Application of Polymers in Biomedical
		CH408	Specialty Polymers
		CH412	Thermoplastic Elastomers
		CH414	Non-woven Technology
		CH418	Application of Nanotechnology in Polymers
		CH420	Inorganic Polymers

2. Minor in Petrochemical Engineering

A] For B.Tech. Chemical Engineering

Student must complete 20 Additional Credits from the following pool of subjects to get minor specialization certificate in Petrochemical Engineering

Electives	
Subject Code	**Name of Subject**
CH307	Petroleum Refining Engineering
CH315	Plastic Technology
CH312	Polymer Processing Techniques
CH318	Petrochemical Engineering
CH324	Heat Exchangers
CH409	Plant Engineering and Process Economics
CH411	Advanced Mass Transfer Operations
CH421	Polymer Reaction Engineering
CH427	Combustion Engineering
CH429	Energy Resources
CH406	Catalysis
CH410	Process Engineering and Design
CH426	Biofuel Engineering
CH428	Energy Conservation and Recycling

B] For Other Disciplines

Student must complete 24 Credits Additional Credits from the following pool of subjects to get minor specialization certificate in Petrochemical Engineering. Core Subjects are compulsory.

Core		**Electives**	
Subject Codes	**Name of Subject**	**Subject Code**	**Name of Subject**
CH303	Mass Transfer I	CH307	Petroleum Refining Engineering
CH304	Mass Transfer II	CH315	Plastic Technology
		CH312	Polymer Processing Techniques
		CH318	Petrochemical Engineering
		CH324	Heat Exchangers

		CH409	Plant Engineering and Process Economics
		CH411	Advanced Mass Transfer Operations
		CH421	Polymer Reaction Engineering
		CH427	Combustion Engineering
		CH429	Energy Resources
		CH406	Catalysis
		CH410	Process Engineering and Design
		CH426	Biofuel Engineering
		CH428	Energy Conservation and Recycling

3. Minor in Chemical Engineering (For Other Disciplines)

Student must complete 24 Credits Additional Credits from the following pool of subjects to get minor specialization certificate in Petrochemical Engineering. Core Subjects are compulsory.

Core		**Electives**	
Subject Codes	**Name of Subject**	**Subject Code**	**Name of Subject**
CH201	Chemical Engineering Process Calculations	CH202	Fluid Mechanics
CH203	Transport Phenomena	CH204	Chemical Reaction Engineering-1
		CH206	Mechanical Operations
		CH208	Heat Transfer
		CH303	Mass Transfer-1
		CH302	Chemical Reaction Engineering-2
		CH304	Mass Transfer-2
		CH306	Chemical Process Technology
		CH321	Numerical Methods in Chemical Engineering
		CH409	Plant Engineering and Process Economics
		CH411	Advanced Mass Transfer Operations
		CH410	Process Engineering and Design
		CH424	Safety & Hazards in Chemical Industries

3rd Semester

1. Subject Code: **PE251** Course Title: **Engineering Materials & Metallurgy**
2. Contact Hours: L: 03 T: 00 P: 02
3. Examination Duration (Hrs.): Theory: 03 Practical: 00
4. Relative Weight: CWS: 15 PRS: 15 MTE: 30 ETE: 40 PRE: 00
5. Credits: 04
6. Semester: ODD-III
7. Subject Area: AEC
8. Pre-requisite: NIL
9. Objective: To provide students the knowledge about the properties of materials that are controlled by structure and bonding at the atomic-scale and by features at the microstructural and macroscopic levels.

10. Course Outcomes: After completing this course, students would be able to:

1. Understand the structure of metals in terms of their crystal structure and identify the mechanical properties of the materials based on crystal imperfections.
2. Identify the effect of alloying on the material properties and different types of corrosion.
3. Understand solidification of metals and alloys and effect of various heat treatment methids on metals.
4. Identify different types of fractures and their causes for design purpose.

11. Details of Course:

S. No.	Contents	Contact Hours
1	Structure of metals: Crystal structure, miller indices for cubic and HCP crystals. Crystal imperfections and their effect on mechanical properties of the material. Plastic deformation of single and poly-crystalline materials.	7
2	Materials: Plain carbon steels, Effect of alloying elements; properties and uses, Tool steels, Stainless Steels, Wear resisting steels. Composition, properties, and use of non-ferrous alloys e.g. Aluminium, Copper and Zinc alloys. Corrosion: Types of corrosion, Galvanic cell, rusting of Iron, methods of protection from corrosion.	7
3	Solidification: Phases in metal system, lever rule, solidification of metal and alloys, solid solution, eutectic, eutectoid and inter-metallic compounds, Iron carbon equilibrium diagram, TTT-diagram. Heat Treatment: Heat treatment of Ferrous and Nonferrous materials, case hardening. Strengthening mechanisms	7
4	Fracture: Types of Fracture of metals and alloys, brittle and ductile, fracture, fatigue failure, effect of alloying elements, design consideration.	7

	Creep: Basic consideration in the selection of material for high and low temperature service, Creep curve, effect of material variables on creep properties, brittle failure at low temperature	
5	Composite materials: Classification of the Composite materials based on the reinforcement, characteristics, applications of composite materials in industry.	7
6	Powder Metallurgy: Principles, techniques, application and advantages. Surface treatment.	7

Suggested Books

S. No.	Name of Books/Authors/Publisher	Year of Publication/Reprint
1	Materials science and engineering : An introduction/ William D. Callister/ John Wiley & Sons	2017
2	Material Science &Engineering/ V.Raghavan/ Prentice Hall India learning Pvt.	2015
3	Material Science &Engineering/ William F. Smith, J. Hashemi, R. Prakash/ McGraw Hill	2013

1. Subject Code: **CH201** Course Title: **Chemical Engineering Process Calculations**
2. Contact Hours: L: 03 T: 01 P: 00
3. Examination Duration (Hrs.): Theory: 03 Tutorial: 00 Practical: 00
4. Relative Weight: CWS: 25 PRS: 00 MTE: 25 ETE: 50 PRE: 00
5. Credits: 04
6. Semester: ODD-III
7. Subject Area: DCC
8. Pre-requisite: NIL
9. Objective: :To present to the students, an introduction to the chemical engineering calculations, establish mathematical methodologies for the computation of material balances, energy balances and to present an overview of industrial chemical processes.
10. Course Outcomes: After completing this course, students would be able to:
    1. Accustomed with stoichiometric and composition relationship including limiting-excess- reactant, conversion and yield., equations of state and properties of gases and liquids.
    2. Develop command on working with elementary flow-sheets, material balance calculations without Chemical Reactions.
    3. Expertise the working on material balance calculations with chemical reactions and involving concepts like recycle, bypass and purge.
    4. Resolve problems related to energy balance calculations without and with chemical reactions.
    5. Develop a command over process calculations relevant to different design problems in real time industrial processes.

11. Details of Course:

S. No.	Content	Contact Hours
1	Introduction to Chemical Engineering Calculations: unit & dimensions, conversion of units, mole concept, basic concept, stoichiometric and composition relationship, limiting-excess-reactant, conversion and yield.	7
2	Material Balance: Without Chemical reaction - ideal gas-law calculations, real-gas relationships, vapour pressure of immiscible liquids, solutions and problems based on Raoult's, Henry & Dalton's Law. Absolute humidity, relative humidity, saturation, dry bulb temperature, wet bulb temperature, adiabatic saturation temperature & use of psychometric chart.	7
3	Material Balance: With chemical reaction- combustion, gas-synthesis, acid-alkali production recycle, purge, bypass in batch, stagewise and continuous operations in systems with or without chemical reaction.	7
4	Energy Balance: Review of thermo-physics, thermochemistry-law of constant heat summation. Hess's Law, standard heat of reaction, combustion and formation, problems using Hess Law.	7
5	Energy Balance: Heat balances for non-reacting processes and reaction processes. Theoretical flame temperature, Adiabatic reaction temperature, flame temperature, combustion calculation.	7
6	Applications of material and energy balances: Applied to industrial processes	7

Suggested Books:

S. No.	Name of Authors/ Books /Publishers	Year of Publication
1	Basic Principles and Calculations in Chemical Engineering/ D.M. Himmelblau,/ Prentice Hall of India.	2012
2	Stoichiometry and Process Calculations/ K.V. Narayanan and B. Lakshmikutty / Prentice Hall of India.	2006
3	Stoichiometry/ B.I. Bhatt and S.M. Vora/ Tata McGraw-Hill	2004
4	Elementary Principles of Chemical Processes/ R.M. Felder and R.W. Rousseau/ John Wiley	2016

1. Subject Code: **CH203** Course Title: **Transport Phenomena**
2. Contact Hours: L: 03 T: 01 P: 00
3. Examination Duration (Hrs.): Theory: 03 Practical: 00
4. Relative Weight: CWS: 25 PRS: 00 MTE: 25 ETE: 50 PRE: 00
5. Credits: 04
6. Semester: ODD-III
7. Subject Area: DCC
8. Pre-requisite: Nil
9. Objective: To impart knowledge about transport phenomena in chemical engineering, analogy of different transport

processes and how to solve problems of transport phenomena

10. Course Outcomes: After completing this course, students would be able to:

1. Identify the analogies and similarities between momentum, heat and mass transport.
2. Solve momentum balance problems for Newtonian fluids.
3. Solve momentum balance equations for Newtonian and Non-Newtonian fluids
4. Grasps the concepts of heat transfer and solve problems related to heat transfer.
5. Understand the concepts of mass transfer and solve problems related to mass transfer.

11. Details of Course:

S. No.	Contents	Contact Hours
1	Introduction of transport phenomena, similarities and analogies among momentum transport, heat transport and mass transport. Basics of vector and tensors, different operations and identities of vectors and tensors used in transport phenomena	5
2	Basics of momentum transport, different axioms of momentum transport, Axiom 1 mass is conversed, Axiom 2 momentum is conversed, different models representing flow behavior of fluids. Coordinate systems, selection of control volumes. Solution of momentum balance problems using shell momentum balance for Newtonian fluids.	11
3	Equation of motion, Navier-stokes equation, Euler's equation, Solutions of momentum balance problems using Equation of motion and Navier stokes equation for Newtonian and non-Newtonian fluids (Power law and Bingham plastics fluids)	8
4	Basic concepts of heat transfer, Fourier's law of conduction, Newton's law of cooling, solution of heat transfer problems using shell heat balance, Equation of Energy, Equation of thermal energy, Viscous heat of dissipation, Solution of heat transfer problems using shell energy balance approach, Solution of heat transfer problems using Equation of Energy	10
5	Basic concepts of mass transfer, mass and molar fluxes, convective and diffusive fluxes and their correlation, Fick's law of diffusion, Equation of continuity for component balance, solution of mass transport problems using shell mass balance approach, solution of mass transport problems using equation of continuity	8

Suggested Books

S. No.	Name of Books/Authors/Publisher	Year of Publication/Reprint
1	Transport Phenomena 2nd edition/ R. Byron Bird, Warren E. Stewart, Edwin N. Lightfoot/ John Wiley & Sons.	2006

2	Transport Phenomena Fundamentals/ Joel L. Plawsky/ CRC Press	2020
3	Introduction to Transport Phenomena: Momentum, Heat and Mass/ B. Raj/ PHI Learning Pvt. Ltd.	2012

1. Subject Code: **CH205** Course Title: **Chemical Engineering Thermodynamics**
2. Contact Hours: L: 03 T: 00 P: 02
3. Examination Duration (Hrs.): Theory: 03 Practical: 00
4. Relative Weight: CWS: 15 PRS: 15 MTE: 30 ETE: 40 PRE: 00
5. Credits: 04
6. Semester: ODD-III
7. Subject Area: DCC
8. Pre-requisite: NIL
9. Objective: To familiarize the students with concepts of chemical engineering thermodynamics.
10. Course Outcomes: After completing this course, students would be able to:

1 Explain the Basic concepts of Chemical Engineering Thermodynamics, First law, Second law.

2. Derive the mathematical expressions, laws and correlations of chemical engineering thermodynamics.

3. Apply the Concepts of thermodynamics to calculate the efficiency of engines and evaluate the thermodynamic state of the system.

4. Derive the mathematical expressions, laws and correlations of solution thermodynamics.

11. Details of Course:

S. No.	Contents	Contact Hours
1	Fundamental concepts and definitions, Temperature and zeroth law of thermodynamics, Equation of states, P-V-T- relationships and application, First law of thermodynamics: Application of first law to different processes in close and open systems, Limitations of first law	8
2	Second law of thermodynamics, entropy concept, entropy and lost work calculations, Microscopic interpretation of entropy, Mathematical statement of second law, Carnot cycle for an ideal gas, Refrigeration cycle, criterion of irreversibility, Third law of thermodynamics and its applications, free energy functions and their significance in phase and chemical equilibria.	9
3	Thermodynamic property relations: Maxwell relations, Joule-Thomson coefficient, Clasius-Clapeyron equation, thermodynamic diagrams; partial molar properties, fugacity, activity and activity coefficients, variation of activity coefficient with temperature and composition, fugacity of liquid and solid, fugacity coefficient for pure species and solution, generalized correlations for fugacity coefficient, dependence of fugacity on temperatures and pressure.	9

4	Phase Equilibria: Predicting VLE of systems, VLE at low to moderate pressures, Calculation of the VLE data for a binary mixture, VLE at high pressures. Gibbs-Duhem equation and its application to vapour liquid equilibria, Thermodynamic consistency.	8
5	Chemical Reaction Equilibria: Criterion of chemical reaction equilibrium, application of equilibrium criteria to chemical reactions, the standard Gibbs energy change and the equilibrium constant, effect of temperature on the equilibrium constant, equilibrium conversions for single reactions.	8

Suggested Books

S. No.	Name of Books/Authors/Publisher	Year of Publication/Reprint
1	Introduction to Chemical Engineering Thermodynamics/J.M. Smith, H.C. Van Ness, M.M. Abbott, J.M. Smith/ McGraw Hill	2017
2	Chemical Engineering Thermodynamics/Rao/University Press	1997
3	A Textbook of Chemical Engineering Thermodynamics/ K.V. Narayanan/ Prentice – Hall of India Pvt. Ltd.	2013

1. Subject Code: **CH207** Course Title: **Engineering Design and Analysis (Process Equipment Design)**
2. Contact Hours: L: 03 T: 00 P: 02
3. Examination Duration (Hrs.): Theory: 03 Practical: 00
4. Relative Weight: CWS: 15 PRS: 15 MTE: 30 ETE: 40 PRE: 00
5. Credits: 04
6. Semester: ODD-III
7. Subject Area: DCC
8. Pre-requisite: NIL
9. Objective: To impart knowledge about the mechanical design of chemical engineering equipment.

10. Course Outcomes: After completing this course, students would be able to:

1. Identify the Stress-strain relationships of different engineering materials.

2. Understand design considerations of pressure vessels as per their codes.

3. Select bolts for flanges and design them. Inspect the vessels using heads and fringes and carry out different piping calculations to withstand internal and external pressure.

4. Design of shell, skirt, bearing plate and anchor bolts for tall tower and design of different support systems.

5. Design of liquid and gas storage tanks with and without floating roof.

11. Details of Course:

S. No.	Contents	Contact Hours
1	Mechanics of Materials: Stress, strain, biaxial stress; Stress-strain relationship for elastic bodies; Membrane stresses in various types of thin pressure vessels.	8
2	Pressure Vessels: Selection of type of vessels, design considerations, introduction of codes for pressure vessel design, classification of pressure vessels as per codes, design of cylindrical and spherical shells under internal and external pressure, selection and design of closures and heads; Introduction to compensation for opening; Design of jacketed portion of vessels; Design of high pressure mono-block and multilayer vessels.	10
3	Flanges: Selection of gaskets, selection of standard flanges, optimum selection of bolts for flanges, design of flanges. Inspection and testing of vessels using heads and flanges as per code specifications.	4
4	Piping: Pipe thickness calculation under internal and external pressure, introduction to flexibility analysis of piping systems.	4
5	Tall Tower Design: Design of shell, skirt, bearing plate and anchor bolts for tall tower used at high wind and seismic conditions.	6
6	Supports : Design of lug support and saddle support including bearing plates and anchor bolts	3
7	Storage Tanks: Introduction to Indian standards, filling and breathing losses; classification of storage tanks; Design of liquid and gas storage tanks with and without floating roof.	7

* Note: This is an OPEN BOOK EXAMINATION. The students are allowed to consult IS Codes, Text books, Reference books and bound lecture notes certified by the teacher concerned

Suggested Books:

S. No.	Name of Authors / Books / Publisher	Year of Publication
1	Chemical Process Equipment Design/ J.A. Shaeiwitz, R. Turton/ Prentice Hall	2017
2	Introduction of Chemical Equipment Design / B. C. Bhattacharya/ CBS Publisher.	2009
3	I.S.:2825-1969 Code for Unfired Pressure Vessels/ Bureau of Indian Standards.	1969
4	I.S.:803-1962 Code of Practice for Design, Fabrication and Erection of Vertical Mild Steel Cylindrical Welded Oil Storage Tanks/ Bureau of Indian Standards.	1962
5	Pressure Vessel Design Manual / D. R. Moss/ Gulf Publishers	2012
6	Pressure Vessel Design / D. Annartone/ Springer	2007

4th Semester

1. Subject Code: **EE282a** Course Title: **Process Instrumentation and Control**
2. Contact Hours: L: 03 T: 00 P: 02
3. Examination Duration (Hrs.): Theory: 03 Practical: 00
4. Relative Weight: CWS: 15 PRS: 15 MTE: 30 ETE: 40 PRE: 00
5. Credits: 04
6. Semester: EVEN-IV
7. Subject Area: AEC
8. Pre-requisite: NIL
9. Objective: To familiarize the students with fundamentals of instruments and control system

Course Outcomes: After completing this course, students would be able to

1. Explain working principle of different measuring instruments
2. Describe the specification of different instruments and advantages and disadvantages.
3. Measure different physical parameters like pressure, temperature, flow rate and level etc.
4. Understand of fundamentals of control systems
5. Apply Laplace transform and represent them in block diagram and signal flow graph.
6. Determine the time domain responses of first and second order systems.

11. Details of Course:

S. No.	Contents	Contact Hours
1	Instrumentation: Classification of measuring instruments, Elements of measuring instruments, Instruments for the measurement of temperature, pressure, flow, liquid level, and moisture content, Instruments and sensors for online measurements.	8
2	Control: General Principles of process control, time domain, Laplace domain and frequency domain dynamics and control Linear Open-loop Systems: Laplace domain analysis of first and second orders systems, linearization, response to step, pulse, impulse and ramp inputs, physical examples of first and second order systems such as thermocouple, level tank, U-tube manometer, etc., interacting and non-interacting systems, distributed and lumped parameter systems, dead time.	8
3	Linear Closed-loop Systems: Controllers and final control elements, different types of control valves and their characteristics, development of block diagram, transient response of simple control systems, stability in Laplace domain.	9
4	Frequency Response: frequency domain analysis, control system design by frequency response, bode stability criterion, different methods of tuning of controllers.	9
5	Process Applications: Temperature control, level control, flow control, pressure control, concentration control in chemical industries, application to equipment such as distillation-columns, reactors, etc.	8

Suggested Books

S. No.	Name of Books/Authors/Publisher	Year of Publication/Reprint
1	Chemical Process Control: An Introduction to Theory and Practice/ G. Stephanopoulos/ Prentice-Hall	2013
2	Process Control: Modeling, Design, and Simulation/B. Wayne Bequette/ Prentice Hall Professional	2003
3	Modern Control Engineering, 5th Ed/ K. Ogata/ Pearson	2010
4	Instrumentation for Process Measurement & Control, 3rd Ed./ Norman A Anderson/ CRC Press	1997

1. Subject Code: **CH202** Course Title: **Fluid Mechanics**
2. Contact Hours: L: 03 T: 00 P: 02
3. Examination Duration (Hrs.): Theory: 03 Practical: 00
4. Relative Weight: CWS: 15 PRS: 15 MTE: 30 ETE: 40 PRE: 00
5. Credits: 04
6. Semester: EVEN-IV
7. Subject Area: DCC
8. Pre-requisite: NIL
9. Objective: To impart knowledge to the students about fluid mechanics and their applications

Course Outcomes: After completing this course, students would be able to

1. Explain the basic concepts of Fluid mechanics, types of flow, types of fluid, Newtonian, Non-Newtonian Fluids etc.
2. Derive the different mathematical correlations, models used in fluid mechanics
3. Design the fluid channels by using the Concepts of fluid mechanics
4. Measure flow rate of fluids by using flow measuring equipment
5. Explain the concepts of drag and fluidization.
6. Design and use of different hydraulic equipment

11. Details of Course:

S. No.	**Contents**	**Contact Hours**
1	Normal forces in fluids, principles governing fluid flow, Newtonian and Non-Newtonian fluids, laminar and turbulent flows; pressure drop and friction factor; velocity profiles, nature of turbulence, eddy viscosity.	9
2	Flow in boundary layers, basic equation of fluid flow, conservation of mass, momentum and energy- integral and differential approaches, Bernoulli's Equations.	9
3	Derivation of Navier-Stokes equation, dimensional analysis; dimensionless numbers and their physical significance, drag force and drag coefficient; terminal and settling velocities; hindered settling, forces on submerged bodies, buoyancy and stability.	10

4	Techniques of flow measurement: pitot tube, orifice meter, venture meter, rota-meter, notches, wet gas meter, fluid machinery**:** pumps, blowers and compressors.	8
5	Mixing of fluids: Types of mixers and their selection; power requirements.	6

Suggested Books

S. No.	Name of Books/Authors/Publisher	Year of Publication/reprint
1	Unit Operations in Chemical Engineering/ W.L. McCabe, J.C. Smith, and P. Harriot/ McGraw Hill.	2017
3	Fluid mechanics for chemical Engineers/ Nevers Noel de/ McGraw Hill.	2012
4	Fox & McDonald Introduction to Fluid Mechanics/P.J. Pritcard/John Wiley and sons.	2011

1. Subject Code: **CH204** Course Title: **Chemical Reaction Engineering -I**
2. Contact Hours: L: 03 T: 00 P: 02
3. Examination Duration (Hrs.): Theory: 03 Practical: 00
4. Relative Weight: CWS: 15 PRS: 15 MTE: 30 ETE: 40 PRE: 00
5. Credits: 04
6. Semester: EVEN-IV
7. Subject Area: DCC
8. Pre-requisite: NIL
9. Objective: To impart knowledge to the students about chemical reaction engineering.

10. Course Outcomes: After completing this course, students would be able to

1. Explain the fundamentals of kinetics including definitions of rate forms of rate expressions and relationship between moles, concentration, extent of reaction and conversion.

2. Apply stoichiometry in combination with a rate law to study and develop rate expressions from elementary step mechanism.

3. Determine rate expressions by analysing reactor data including integral and differential analysis step mechanism.

4. Derive batch, CSTR, and PFR performance equations from general material balances and to do performance calculations on single, isothermal plug-flow, CSTR, and batch reactors for a single homogeneous or heterogeneous reaction from either rate data or a rate expression.

5.Identify & enlist the non-ideal behaviours of industrial reactors and their basics.

11. Details of Course:

S. No.	**Contents**	**Contact Hours**

1	Introduction: Reaction rate; Kinetics of homogeneous reaction: Concentration-dependent term of a rate equation, single and multiple reaction, Elementary & Non-elementary reactions, kinetic view of equilibrium for elementary reactions, Molecularity, order of reaction, Representation of an elementary reaction, Kinetics for non-elementary reactions, Temperature dependent term of a rate equation: Arrhenius law, Collision theory, Transition-state Theory	10
2	Interpretation of batch reactor data: Constant-volume batch reactor, Integral method of data analysis: General Procedure, Irreversible unimolecular-type First-order Reaction, Irreversible Bimolecular-type Second-order Reactions, Empirical Rate Equations of n^{th} Order, Zero-order Reactions, Overall Order of Irreversible Reactions from the Half-life	10
3	Irreversible Reactions in Parallel, Autocatalytic reactions, Irreversible reactions in series, First-order Reversible Reactions, Differential method of Analysis of data: Analysis of the rate equation, Varying-Volume Batch Reactors	8
4	Material balance equation for ideal batch reactor & its use for kinetic interpretation of data and isothermal reactor design for single reactions. Analysis of CSTR & PFR and their use for kinetic interpretation and design, Comparison of batch reactor, CSTR & PFR	6
5	Concept of adiabatic & non-isothermal operations; Non Ideality**:** Basics of non-ideal flow, residence time distribution, States of segregation, Measurement and application of RTD, Conversion in non-ideal reactors.	8

Suggested Books

S. No.	Name of Books/Authors/Publisher	Year of Publication/Reprint
1	Chemical Reaction Engineering/Levenspiel O./ Wiley Eastern Ltd. 3rd Ed.	2006
2	Essentials of Chemical Reaction Engineering/Fogler/ Pearson	2014
3	Introduction to Chemical Engineering Kinetics and Reactor Design/ Charles G. Hill, Thatcher W. Root/ Wiley	2014

1. Subject Code: **CH206** Course Title: **Mechanical Operations**
2. Contact Hours: L: 03 T: 00 P: 02
3. Examination Duration (Hrs.): Theory: 03 Practical: 00
4. Relative Weight: CWS: 15 PRS: 15 MTE: 30 ETE: 40 PRE: 00
5. Credits: 04
6. Semester: EVEN-IV
7. Subject Area: DCC
8. Pre-requisite: NIL

9. Objective: To impart knowledge on particle size analysis, size reduction, separation of solid particles from fluids and flow through porous media.

10. Course Outcomes : After Completing this course, student would be able to:

1. Identify the size reduction process and separation process based on the particle size.

2. Design the Agitator vessels for mixing fluids

3. Analyse various filtration process

4. Construct the settling tanks for separation of solid and liquid.

5. Describe various solid conveying processes.

11. Details of Course:

S. No.	Contents	Contact Hours
1	Particle Size Analysis: Sieve analysis, size distribution, size averaging and equivalence, size estimation in sub-sieve range Size Reduction: Theory of crushing and grinding, crushing and grinding equipment and their selection. Screening: Capacity and Effectiveness of a screen, calculation of average size of particles in mixture by screen analysis, types of screens.	10
2	Agitation and Mixing: Agitation of low viscosity particle suspensions: axial flow impellers, radial flow impellers, close-clearance stirrer, unbaffled tanks, baffled tanks, basic idea for designing agitators. power consumption in agitation. Mixing of Solids: Types of mixers, power requirements, mixing index. Mixers for free flowing solids	10
3	Filtration: Flow through filter cake and medium, washing and drying of cake, filter aids, selection of filtration equipment, constant rate and constant pressure filtration, micro filtration	6
4	Settling: Motion of particles through fluids, Terminal velocity, hindered settling, Stoke's law, gravity settling processes: Classifiers, clarifiers, thickeners, flocculation, rate of sedimentation. Centrifugal Settling processes: Cyclones, hydro clones, decanters, principles of centrifugal sedimentation	8
5	Fluid-Solid Conveying: Pneumatic and hydraulic transport of solids, general characteristics and flow relations Fluidization: Fluidization and fluidized bed, conditions for fluidization, Ergun equation and Kozeny-Carman equation, minimum fluidization velocity, types of fluidization, industrial applications.	8

Suggested Books:

S. No.	Name of Authors/ Books /Publishers	Year of Publication
1	Unit Operations in Chemical Engineering/ W.L. McCabe, J.C. Smith, and P. Harriot/ McGraw Hill.	2017

2	Coulson J. H. and Richardson J.F., "Chemical Engineering, Vol. II", Butterworth-Heinemann.	2015
3	Brown G. G., "Unit Operations", CBS publishers.	1995
4	Narayanan C.M. and Bhattacharya B.C., "Mechanical Operations for Chemical Engineers", Khanna publishers.	1992

1. Subject Code: **CH208** Course Title: **Heat Transfer**
2. Contact Hours: L: 03 T: 00 P: 02
3. Examination Duration (Hrs.): Theory: 03 Practical: 00
4. Relative Weight: CWS: 15 PRS: 15 MTE: 30 ETE: 40 PRE: 00
5. Credits: 04
6. Semester: EVEN-IV
7. Subject Area: DCC
8. Pre-requisite: NIL
9. Objective: To impart knowledge to the students about conduction, convection and heat radiation.
10. After completing this course, students would be able to:

1. Explain the fundamentals of basis Heat Transfer operations and their equations.

2. Classified the materials on their thermal conductivity and able to solve the problems related to the conduction heat transfer for different- Geometry.

3. Apply the concepts convection along with the conduction to solve the industrial heat exchange problems involving heat exchanger and condensers.

4. Describe the phenomena of heat exchange between bodies by radiation in absence of any media.

5. Design of different heat exchangers and other process equipment involving heat transfer.

11. Details of Course:

S. No.	Contents	Contact Hours
1	Introduction to heat transfer and involved basic equations.	4
2	Conduction: Review of Fourier's law, thermal conductivity of materials, steady and unsteady state conduction, steady state conditions, equation of planes, cylinders, hollow spheres, and problems related to these cases. Lagging of pipes and other equipment, optimum lagging thickness, heat transfer from extended surfaces (fins).	9
3	Convection: Free and forced convection, Concept of thermal boundary layer, concept of Individual and overall heat transfer coefficients, laminar and turbulent flow, Heat transfer inside & outside tubes with significance of Nusselt, Prandlt, Reynold, Biot, Fourier and Peclet number. Condensation and Boiling: Definition, film wise and drop wise condensation, Nucleate& Film boiling, Different Boiling regimes.	9

4	Radiation: Distribution of radiant energy, Definition of emissivity, absorptivity, Reflectivity and Transmissivity, concept of Black and Grey bodies, Planck's law of monochromatic radiation, Kirchhoff's law, Wein's displacement law, Stefan-Boltzmann Law, Heat exchange by radiation between two simple bodies, two parallel surfaces and between any source and receiver, Salient features of shape factor.	10
5	Heat Exchangers: Classification of heat exchangers, the construction, specification and applications, LMTD in single pass, parallel and counter flow arrangements, cross-flow arrangements, use of correction factor. Evaporation: Heat transfer to vaporization processes, single and multiple effect evaporations. Various types of evaporators	10

Suggested Books

S. No.	Name of Books/Authors/Publisher	Year of Publication/Reprint
1	Fundamentals of Heat & Mass Transfer/ Bergman et al/ Wiley India	2011
2	Unit Operations in Chemical Engineering/ W.L. McCabe, J.C. Smith, and P. Harriot/ McGraw Hill.	2017
3	Heat Transfer: Principles & Applications/ Dutta/ Prentice Hall	2000
4	Process Heat Transfer: Principles, Applications and Rules of Thumb, 2nd/R.W. Serth, T.Lestina/ Academic Press	2014
5	Heat Transfer/ Holman/ McGraw Hill	2010

5th Semester

1. Subject Code: **CH301** Course Title: **Polymer Materials**
2. Contact Hours: L: 03 T: 00 P: 02
3. Examination Duration (Hrs.): Theory: 03 Practical: 00
4. Relative Weight: CWS: 15 PRS: 15 MTE: 30 ETE: 40 PRE: 00
5. Credits: 04
6. Semester: ODD-V
7. Subject Area: DCC
8. Pre-requisite: NIL
9. Objective: To impart knowledge of polymerization processes and properties of polymer.

10. Course Outcomes: After completing this course, students would be able to:

1. Describe monomer and functionality, polymerization mechanism and degree of polymerization & techniques

2. Identify various copolymers and design copolymers

3. Describe the need of average molecular weights for polymers and identify the molecular weight by different techniques.

4. Analyse the structure of polymers using modern analytical techniques and describe polymer properties such as rheological and thermal based on their structure

5. Analyse the data of modern testing equipment and describe polymer properties such as mechanical Properties based on their structure.

11. Details of Course:

S. No.	Contents	Contact Hours
1	General introduction to polymer structure: Classification and nomenclature of polymers, monomer and functionality, polymerization and degree of polymerization, Classification of polymerization mechanism, stepwise polymerization, radical chain (addition) polymerization, coordination polymerization, ring opening polymerization	9
2	Copolymer and their types, methods of copolymerization, techniques of polymerization: Bulk, Solution, Suspension & Emulsion, Industrial methods of polymerization, polymerization in homogenous systems, polymerization in heterogeneous systems.	8
3	Polymer molecular weight, and its distribution, method of determination of different molecular weights, Polymer Structure analysis, configuration, conformation of polymers, structure, and properties of amorphous, semi crystalline, and cross-linked polymers	8
4	Thermal properties of polymers, concept of glass transition temperature, melting and softening temperature, thermal analysis of polymers by TGA, DSC, DMTA. Polymer Crystallization and Methods of	9

	determination of crystallinity. Viscoelastic properties of Polymer, creep, stress relaxation, fatigue of polymeric materials. mechanical models	
5	Mechanical properties of polymers strength (creep, fatigue, stress relaxation tensile, flexural and compressive), hardness, resilience, impact properties, factors affecting these properties, methods of determination of these properties. Electrical and Optical properties of polymers	8

Suggested Books

S. No.	Name of Books/Authors/Publisher	Year of Publication/Reprint
1	Textbook of Polymer Science/ F.W. Billmeyer/ John Wiley	2008
2	Polymer Science/ V.R. Gowarikar/ New Age International	2016
3	Properties of Polymer/ D.W. van Krevelen/ Elsevier	2003
4	Principle of Polymerization/ G Odian/ Wiley	2004
5.	Plastic Materials/ J A Brydson/ Butterworth-Heinemann.	2000
6.	Handbook of Plastics Testing and Failure Analysis/ Vishu Shah/ John Wiley & Sons	2007

1. Subject Code: **CH303** Course Title: **Mass Transfer-I**
2. Contact Hours: L: 03 T: 00 P: 02
3. Examination Duration (Hrs.): Theory: 03 Practical: 00
4. Relative Weight: CWS: 15 PRS: 15 MTE: 30 ETE: 40 PRE: 00
5. Credits: 04
6. Semester: ODD-V
7. Subject Area: DCC
8. Pre-requisite: NIL
9. Objective: To familiarize students about mass transfer operations.
10. Course Outcomes: After completing this course, students would be able to

1. Explain the importance of various mass transfer operations and their difference from mechanical separation processes.

2. Describe the phenomena of diffusion and its role in transfer of mass in in gas, liquid and solids.

3. Define the concept of various mass transfer theories and determine mass transfer coefficients.

4. Apply fundamental principles of absorption, humidification and drying in industrial applications.

5. Design staged and continuous contactors for various gas-liquid contact operations.

11. Details of Course:

S. No.	Contents	Contact Hours
1	Introduction: Mass transfer operations and their classification, Diffusion: molecular diffusion, Fick' law of diffusion, equimolal counter diffusion, diffusion of A through stagnant non-diffusing B, diffusion in gases, molecular diffusion in liquids, measurement and estimation of diffusivity mass transfer between gas and liquid phases, Individual and overall mass transfer coefficients.	12
2	Interphase Mass Transfer: Theories of Mass transfer, Film theory, penetration theory and surface renewal theory. Equipment used in gas-liquid operations, co-current and countercurrent absorption processes, transfer unit: HETP,HTU and NTU concepts.	10
3	Gas Absorption: Design of plate and packed absorption columns, Scrubbers, Non-isothermal absorption, Simultaneous heat and mass transfer.	6
4	Drying of Solids: Rate of drying curves, through circulation drying, Continuous drying, Types of dryer	6
5	Humidification Operations: VLE & Enthalpy, Reference substance plots, vapour gas mixtures, concept of adiabatic saturation, psychometric charts, adiabatic operations humidification operations and water cooling operations. Dehumidification Equipments: water cooling towers & spray chambers	8

Suggested Books

S. No.	Name of Books/Authors/Publisher	Year of Publication/Reprint
1	Mass Transfer Operations/ Treybal/ McGraw Hill	2015
2	Unit Operations in Chemical Engineering/ W.L. McCabe, J.C. Smith, and P. Harriot/ McGraw Hill.	2017
3	Principles of Mass Transfer/ Sharma/ Prentice Hall of India	2007
4	Principles of Mass Transfer & Separation Process/ Dutta/ Prentice Hall of India	2001
5	Elements of Mass Transfer/Anatharaman & Sheriffa Begum/ Prentice Hall of India	2005

6th Semester

1. Subject Code: **CH302** Course Title: **Chemical Reaction Engineering-II**
2. Contact Hours: L: 03 T: 00 P: 02
3. Examination Duration (Hrs.): Theory: 03 Practical: 00
4. Relative Weight: CWS: 15 PRS: 15 MTE: 30 ETE: 40 PRE: 00
5. Credits: 04
6. Semester: EVEN-VI
7. Subject Area: DCC
8. Pre-requisite: NIL
9. Objective: To enable the students to learn advance chemical reaction engineering including biochemical reactions.

10. Course Outcomes: After completing this course, students would be able to:

1. Explain the fundamentals of catalyst preparation, its characterization and testing and different steps involved in a catalytic reaction.

2. Explain adsorption and adsorption isotherms and apply this knowledge in hetrogeneous reactor design.

3. Describe the fluid solid catalytic reaction kinetics including the reaction within porous catalyst.

4. Determine fluid-fluid reaction rate equations and their application to the design of reactors

5. Explain the principles of bio-chemical reactions and calculate the optimum process of fermenters.

11. Details of Course :

S. No.	Contents	Contact Hours
1	Kinetics of Heterogeneous Reactions: Basic idea of catalysis, Catalyst properties, Catalytic specificity, Preparation, Testing and characterization of catalysts, Steps in catalytic reaction, Adsorption, Adsorption isotherms, Catalyst poisoning and catalyst regeneration.	8
2	Diffusion Through Porous Catalyst Particles: Fluid solid catalytic reaction kinetics, external transport process, Reaction & diffusion within porous catalysts, Effective diffusivity.	8
3	Kinetics of Fluid-Particle Reactions: Modelling of gas-solid non-catalytic reactions and determination of parameters, Combination of resistances & determination of rate controlling step.	10
4	Kinetics & Design of Fluid-Fluid Reactions: Interface behavior for liquid-phase reaction, Fluid-fluid reaction rate equations, Regimes for different reaction kinetics for liquid-liquid reactions, Concept of Enhancement factor & Hatta Number, Applications of fluid-fluid reaction rate equations to design the reactors, Fluid-solid non-catalytic reactors.	7

5	Design of Heterogeneous Reactors: Analysis of rate data design outline and selection of fixed bed, fluidized bed and slurry reactors, Reactor systems and design for gas-liquid-solid non-catalytic system. Bioreactors: Classification different bioreactors e.g. batch and continuous, mechanically and non-mechanically agitated. Design and analysis of Bioreactors, Scale up considerations of bioprocesses	7

Suggested Books

S. No.	Name of Books/Authors/Publisher	Year of Publication/Reprint
1	Elements of Chemical Reaction Engineering/ H. Scott Fogler/ Prentice Hall	2005
2	Encyclopedia of Chemical Technology/ Kirk-Othmer/ Wiley	2014
3	The Engineering of Chemical Reactions/ Schmidt/ Oxford University Press	2005
4	Elements of Reaction Engineering/ R.P.S. Srivastava/ Khanna Publishers	2008
5	Chemical Engineering Kinetics, 3rd Ed./ Smith J.M./ McGraw Hill	1981

1. Subject Code: **CH304** Course Title: **Mass Transfer-II**
2. Contact Hours: L: 03 T: 00 P: 02
3. Examination Duration (Hrs.): Theory: 03 Practical: 02
4. Relative Weight: CWS: 15 PRS: 15 MTE: 30 ETE: 40 PRE: 00
5. Credits: 04
6. Semester: EVEN-VI
7. Subject Area: DCC
8. Pre-requisite: NIL
9. Objective: To familiarize students about different advance mass transfer operations.

Course Outcomes: After completing this course, students would be able to:

1. Explain the fundamentals of Distillation and Distinguish between the type of distillation required to be carried out in real time situation.
2. Apply the knowledge of distillation principles in the design of fractionation column for a practical problem.
3. Define the terms associated with Liquid-Liquid extraction, Equilibrium diagram its physical significance and different LLE equipment.
4. Apply the concept of solid-liquid extraction (leaching) and crystallization and their importance in industries.
5. Differentiate between chemisorption and physical adsorption. Data fitting in different adsorption isotherm.

11. Details of Course:

S. No.	Contents	Contact Hours
1	Distillation: Vapor Liquid Equilibria, Raoult's Law, relative volatility, Distillation Types: Batch and Continuous, Analysis of binary distillation in trayed towers: McCabe Thele Method, Stepwise procedure to determine the number of theoretical trays Enthalpy-concentration diagrams, simple distillation, continuous rectification of binary systems. Multistage tray tower design: McCabe and Thiele and Ponchon Savarit methods, tray efficiency, Azeotropic, extractive and steam distillation.	14
2	Liquid-liquid extraction: Extraction equipment, equilibrium diagram, choice of solvent, Single stage and multistage counter-current extraction with/without reflux, Equipment used in liquid-liquid extraction.	10
3	Solid liquid extraction: Leaching, Factors affecting the rate of leaching, Leaching Equipment	5
4.	Adsorption: Types of Adsorption, Desirable qualities of adsorbents, Adsorption equilibria- single species- Langmuir, Freundlich isotherms, Adsorption operations –single stage and multi stage.	8
5	Crystallization: Methods of forming nuclei in solution and crystal growth, Crystallizers	5

Suggested Books

S. No.	Name of Books/Authors/Publisher	Year of Publication/Reprint
1	Mass Transfer Operations/ Treybal/ McGraw Hill	2015
2	Unit Operations in Chemical Engineering/ W.L. McCabe, J.C. Smith, and P. Harriot/ McGraw Hill.	2017
3	Principles of Mass Transfer/ Sharma/ Prentice Hall of India	2007
4	Principles of Mass Transfer & Separation Process/ Dutta/ Prentice Hall of India	2001
5	Elements of Mass Transfer/Anatharaman & Sheriffa Begum/ Prentice Hall of India	2005

1. Subject Code: **CH306** Course Title: **Chemical Process Technology**
2. Contact Hours: L: 03 T: 00 P: 02
3. Examination Duration (Hrs.): Theory: 03 Practical: 00
4. Relative Weight: CWS: 15 PRS: 15 MTE: 30 ETE: 40 PRE: 00
5. Credits: 04
6. Semester: EVEN-VI

7. Subject Area: DCC
8. Pre-requisite: NIL
9. Objective: To familiarize students about oils, fats, agro based products etc.
10. Course Outcomes: After completing this course, students would be able to

1. Explain the chemical processes by using chemical flow charts.
2. Develop the flow chart for given chemical processes.
3. Describe process involving the production of different products in chemical plants.
4. Identify the operational parameters and describe their effects on the system.
5. Evaluate the current scenario of chemical industry based on total demand in market and production capacity.

11. Details of Course:

S. No.	Contents	Contact Hours
1	Representation of steady-state flow sheets for the chemical plant	5
2	Oils and fats: Major oil seeds production in India; Methods of oil extraction, Hydrogenation of oils. Soaps and detergents: cleaning action, soap and detergent manufacturing, recovery of glycerine, Fat-splitting.	9
3	Food processing and agro based Industries: Cane Sugar production and manufacturing technology, cane sugar refining, baggasse utilization, Fermentation of molasses.	9
4	Inorganic chemical industries; sulfuric acid, sodium hydroxide, ammonia and its allied products. Fertilizers: Classification of fertilizers, manufacture of ammonia based fertilizers, manufacture of phosphate fertilizers and potash fertilizers, N-P-K values.	9
5	Pulp and Paper Industries: Kraft pulp process, Sulphite pulp process, Production of paper. Recent advancements in chemical process technology.	10

Suggested Books

S. No.	Name of Books/Authors/Publisher	Year of Publication /Reprint
1	Chemical Process Technology 2nd Ed/ Moulijn / Wiley	2013
2	Outlines of Chemical Technology/ C. E. Dryden, and M.G. Rao, (Ed.)/ Affiliated East West Press	2017

3	Sherve's Chemical Process Industries/Austin/ Mc-GrawHill	2012
4	Encyclopedia of Chemical Technology; 27 Vol Set/Kirk & Othmer (Ed.)/ Wiley	2004

7th Semester

1. Subject Code: **CH401** Course Title**: B.Tech Project-I**

2. Contact Hours: L:0 T:0 P:0
3. Examination Duration (Hrs.): Theory: 0 Practical: 0

4. Relative Weight**:** CWS: 0 PRS: 0 MTE: 0 ETE: 0 PRE: 0

5. Credits: 4 6. Semester: VII 7. Subject Area: DCC

8. Pre-requisite: NIL

9. Objective: To familiarize the students to work in group and develop an independent understanding of engineering and analysis of engineering systems. To guide them write and present the work done in a professional manner during the course.

10. Course Outcomes: After completing this course, students would be able to

1. Identify an engineering/research problem, and review the available literature to acquired knowledge relate to problem.
2. Analyse the scientific and engineering approaches used till date to solve similar of problems.
3. Prepare work plan, design experiments or develop/design mathematical models to achieve project objectives.
4. Correlate the knowledge of different subjects studied during B.Tech in solving targeted engineering problem.
5. Present the results achieved, and communicate their findings in terms of technical presentation and technical report writing.

1. Subject Code: **CH403** Course Title: **Training Seminar**

2. Contact Hours: L: 0 T:0 P:0
3. Examination Duration (Hrs.): Theory: 0 Practical: 0

4. Relative Weight**:** CWS: 0 PRS: 0 MTE: 0 ETE: 0 PRE: 0

5. Credits: 2 6. Semester: VII 7. Subject Area: DCC

8. Pre-requisite: NIL

9. Objective: To familiarize the students to the working culture of the industrial system. To make them able to write and present the work done in a professional manner during the course.

10. Course Outcomes: After completing this course, students would be able to:

1. Apply the knowledge acquired during three years of engineering in the actual engineering problems.

2. Address the industrial problems and suggest feasible solutions.

3. Work in team to achieve professional goals in an industry as a part of the industrial system.

8th Semester

1. Subject Code: **CH402** Course Title: **B.Tech project-II**

2. Contact Hours: L:0 T:0 P:0
3. Examination Duration (Hrs.): Theory:0 Practical: 0

4. Relative Weight**:** CWS: 0 PRS: 0 MTE: 0 ETE:0 PRE: 0

5. Credits: 8 6. Semester: VIII 7. Subject Area: DCC

8. Pre-requisite: NIL

9. Objective: To familiarize the students to work in group and develop an independent understanding of engineering and analysis of engineering systems. To guide them to be able to write and present the work done in a professional manner during the course.

10. Course Outcomes: After completing this course, students would be able to

1. Identify an engineering/research problem, and review the available literature to acquired knowledge relate to problem.

2. Analyse the scientific and engineering approaches used till date to solve similar of problems.

3. Prepare work plan, design experiments or develop/design mathematical models to achieve project objectives.

4. Correlate the knowledge of different subjects studied during B.Tech in solving targeted engineering problem.

5. Present the results achieved, and communicate their findings in terms of technical presentation and technical report writing.

Departmental Elective Courses

5th Semester

Elective I and Elective II

1. Subject Code: **CH305** Course Title: **Characterization and Testing of Materials**
2. Contact Hours: L: 03 T: 00 P: 02
3. Examination Duration (Hrs.): Theory: 03 Practical: 00
4. Relative Weight: CWS: 15 PRS: 15 MTE: 30 ETE: 40 PRE: 00

5. Credits: 04
6. Semester: ODD-V
7. Subject Area: DEC/GEC
8. Pre-requisite: NIL
9. Objective: To impart knowledge of Characterization techniques to the students
10. Course Outcomes: After completing this course, students would be able to

1. Describe and Differentiate various testing standards.

2. Identify materials using analytical Instruments.

3. Describe the functions of analytical Instruments

4. Identify the proper testing method to characterize the specific properties of materials.

11. Details of Course:

S. No.	Contents	Contact Hours
1	Application of national and international standards, BIS, ISO, ASTM for testing and their significance	5
2	UV-visible, IR and Raman spectroscopy and its applications in material characterization	8
3	NMR spectroscopy in liquid and solid phase (1H and 13C) and its applications in material characterization,	10
4	Mass spectrometry, separation techniques (GC, LC), structure elucidation of materials based on spectroscopic data	9
5	X-Ray diffraction method, scanning electron microscopy, transmission electron microscopy, and atomic force microscopy method for material characterization	10

Suggested Books:

S. No.	Name of Books/Authors/Publisher/ISBN	Year of Publication /Reprint
1	Polymer Characterization /P. Nicholas Cheremisinoff/ Elsevier/ eBook	1996
2	NMR Spectroscopy of Polymers / Kitayama, Tatsuki, Hatada, Koichi/ Springer	2004
3	Analytical Methods for Polymer Characterization / R. Yang/ CRC Press	2018

1. Subject Code: **CH307** Course Title: **Petroleum Refinery Engineering**
2. Contact Hours: L: 03 T: 01 P: 00
3. Examination Duration (Hrs.): Theory: 03 Practical: 00
4. Relative Weight: CWS: 25 PRS: 00 MTE: 25 ETE: 50 PRE: 00
5. Credits: 04

6. Semester: ODD-V
7. Subject Area: DEC/GEC
8. Pre-requisite: NIL
9. Objective: To familiarize students with knowledge of petroleum, its refining and properties.

10. Course Outcomes: After completing this course, students would be able to

1. Explain the classification of different types of crude oil, their origin and extraction processes.
2. Identify and explain the different petroleum products, their critical properties and testing methods.
3. Correlate the structure of hydrocarbons to the properties of final petroleum products.
4. Explain the adverse effects of the sulphur, nitrogen, oxygen and heavy metal containing compounds present in crude oil/final products on environment, the refining processes, and product transportation/storage.
5. Explain the government regulations (Barat, EURO and TYRE) to limit maximum allowable amount of sulphur containing compounds in the petroleum products.
6. Explain the different units of a refinery such as ADU, VDU, Thermal cracking units, catalytic cracking units, finishing and quality enhancement processes, sulphur removal processes and effluent treatment plants.

11.Details of Course

S. No.	Contents	Contact Hours
1	Concepts of oil refining, Composition of crude oil, refinery feedstocks and products, Physical and Chemical properties, Laboratory tests.	6
2	Evaluation of oil stocks, Dehydration and desalting of crude, Crude Assay ASTM TBP distillations evaluation of crude oil properties, API gravity various average boiling points and mid percent curves, Evaluation of properties of crude oil and its fractions, Design concept of crude oil distillation column design.	9
3	Thermal and Catalytic cracking, Coking and Thermal process, Delayed coking, Catalytic cracking, Cracking reactions, Zeolite catalysts, Cracking Feedstocks and reactors, Effect of process variables, FCC Cracking, Catalyst coking and regeneration, Design concepts, New Designs for Fluidized-Bed Catalytic Cracking Units, Hydrocracking, Catalytic Reforming, Reformer feed reforming reactor design continuous and semi regenerative process.	10
4	Isomerization process, Reactions, Effects of process variables, Alkylation process, Feedstocks, reactions, products, catalysts and effect of process variables, Polymerization, Process and reactions, catalysts and effect of process variables.	8
5	Environmental issues and New trends in petroleum refinery operations, Ecological consideration in petroleum refinery, Waste water treatment, control of air pollution, Alternative energy sources, Biodiesel, Hydrogen energy from biomass.	9

Suggested Books

S. No.	Name of Books/Authors/Publisher	Year of Publication /Reprint
1	Fundamentals of Petroleum Refining/ Fahim, Alsahhaf and Elkilani / Elsevier	2010
2	Petroleum Refining Design and Applications Handbook/ A.K. Coker/ John Wiley & Sons.	2018
3	Petroleum Refining Processes/ James G. Speight, Baki Ozum/ CRC Press	2001
4	Petroleum Refining Technology/ Indra Deo Mall/ CBS	2015

1. Subject Code: **CH309** Course Title: **Chemical Process Simulations**
2. Contact Hours: L: 03 T: 01 P: 00
3. Examination Duration (Hrs.): Theory: 03 Practical: 00
4. Relative Weight: CWS: 25 PRS: 00 MTE: 25 ETE: 50 PRE: 00
5. Credits: 04
6. Semester: ODD-V
7. Subject Area: DEC/GEC
8. Pre-requisite: NIL
9. Objective: To study the modeling & simulation techniques of chemical processes and to gain skills in using process simulators

10. Course Outcomes: After completing this course, students would be able to

1. Identify and apply the different principles of mathematical modelling in design.
2. Apply thermodynamic correlations for the estimation of physical properties of systems.
3. Carry out modelling of reactors under isothermal and non-isothermal conditions.
4. Carry out modelling of different mass transfer equipment.
5. Simulations of the models.

11. Details of Course

S. No.	**Contents**	**Contact Hours**
1	Introduction: Use and scope of mathematical modeling, Principles of model formulation, Role and importance of steady-state and dynamic simulation, Classification of models, Model building, Modeling difficulties, Degree-of-freedom analysis, Selection of design variables, Review of numerical techniques, Model simulation	8
2	Fundamental Laws: Equations of continuity, energy, momentum, and state, Transport properties, Equilibrium and chemical kinetics, Review of thermodynamic correlations for the estimation of physical properties like phase equilibria, bubble and dew points.	8

3	Modeling of Specific Systems-I: Constant and variable holdup CSTRs under isothermal and non-isothermal conditions, Stability analysis, Gas phase pressurized CSTR, Two phase CSTR, Non-isothermal PFR, Batch and semi-batch reactors,	8
4	Modeling of Specific Systems-II: Heat conduction in a bar, Laminar flow of Newtonian liquid in a pipe, Gravity flow tank, Single component vaporizer, Multi-component flash drum, Absorption column, Ideal binary distillation column and non-ideal multi-component distillation column, Batch distillation with holdup etc.	10
5	Simulation: Simulation of the models, Sequential modular approach, Equation oriented approach, Partitioning and tearing, Introduction and use of process simulation software (Aspen Plus/ Aspen Hysys) for flow sheet simulation.	8

Suggested Books

S. No.	Name of Books/Authors/Publisher	Year of Publication /Reprint
1	Process Control: Modeling, Design, and Simulation/ B.W. Bequette/ Prentice Hall Professional.	2003
2	Process Modeling and Simulation for Chemical Engineers: Theory and Practice/ S.R. Upreti/ John Wiley & Sons	2017

1. Subject Code: **CH311** Course Title: **Rheology**
2. Contact Hours: L: 03 T: 01 P: 00
3. Examination Duration (Hrs.): Theory: 03 Practical: 00
4. Relative Weight: CWS: 25 PRS: 00 MTE: 25 ETE: 50 PRE: 00
5. Credits: 04
6. Semester: ODD-V
7. Subject Area: DEC/GEC
8. Pre-requisite: NIL
9. Objective: To enable the students to learn about polymer rheology and their importance.
10. Course Outcomes: After completing this course, students would be able to

    1. Describe the different aspects of polymer rheology and flow viscoelasticity, stress relaxation, creep, stress-strain correlations etc.

    2. Analyse the rheological properties of polymers using mathematical models.

    3. Describe the principals of Rheometers and measure the different Rheological properties

    4. Apply the rheological concepts in the polymer processing.

11. Details of Course

S. No.	Contents	Contact Hours
1	Linear viscoelastic model, stress relaxation and creep, non-linear viscoelasticity - normal stress difference in shear, shear thinning, interrelations between shear functions, extensional thickening, differential-type constitutive equations - single mode differential constitutive equations and multimode constitutive equations for viscoelastic fluids, integral type constitutive equations, rate-type constitutive equations for viscoelastic fluids, material functions for steady state shear flow, oscillatory shear flow, material functions for steady state extensional flow.	10
2	Shear rheometer: sliding plates, falling ball rheometer, concentric cylinder rheometer, cone and plate rheometer, parallel disks, capillary rheometer, slit rheometer and squeezing flow behavior.	8
3	Extensional rheometry: simple extension - end clamps, rotating clamps, buoyancy bath, spinning drop, lubricated compression, planner squzeeing, sheet stretching, multiaxial extension, fiber spinning, tubeless siphon, bubble collapse, stagnation flow.	8
4	Rheology of polymeric liquids: polymer chain conformation, zero shear viscosity, rheology of dilute polymer solutions, entanglement, Repetition Model, effect of long chain branching, effect of molecular weight distribution, temperature dependence.	8
5	Rheology in polymer processing operations: Calendaring and two roll mill, Twin screw extruders, Blow molding, Wire coating, Thermoforming, Sheet extrusion, Internal mixers, Rubber extrusion	8

Suggested Books

S. No.	Name of Books/Authors/Publisher	Year of Publication /Reprint
1	Rheology, Principles, Measurements and Applications/ Christopher W. Macasko/ Wiley VCH	1994
2	Rheology: Concepts, Methods, and Applications/ A.Y. Malkin, A.I. Isayev/ Elsevier	2017
3	Rheology - Volume II/ C. Gallegos / EOLSS Publications.	2010
4	Non-Newtonian Flow and Applied Rheology: Engineering Applications/ R. P. Chhabra, J.F. Richardson/ Butterworth-Heinemann.	2011

1. Subject Code: **CH313** Course Title: **Corrosion Engineering**
2. Contact Hours: L: 03 T: 01 P: 00
3. Examination Duration (Hrs.): Theory: 03 Practical: 00
4. Relative Weight: CWS: 25 PRS: 00 MTE: 25 ETE: 50 PRE: 00
5. Credits: 04
6. Semester: ODD-V

7. Subject Area: DEC/GEC
8. Pre-requisite: NIL
9. Objective: To enable the students to learn about the electrochemistry, chemical and biological aspects of corrosion.

10. Course Outcomes: After completing this course, students would be able to

1. Explain different aspects of corrosions, its causes, effects and preventions.
2. Identify the corrosion in a given equipment body,
3. Conduct testing/observations to evaluate the corrosion in given equipment body.
4. Describe the reaction mechanism/kinetics, electro-chemistry and thermodynamics behind corrosion.
5. Design coatings, inhibitions, cathode protections and other corrosion protection method for given body.
6. Explain the bio-corrosion, its causes, effects and preventions.
7. Explain the metallurgical properties influencing corrosion and Developed and formulate different metal alloys for better corrosion resistance properties.

11. Details of Course

S. No.	Contents	Contact Hours
1	Corrosion, Classification of corrosion, Electrochemistry of corrosion, Galvanic and electrolytic cells, Potential measurements, EMF and Galvanic series, Galvanic corrosion and bimetallic contacts, Eh-pH diagrams, Copper, Aluminium and general corrosion diagrams.	10
2	Electrode kinetics and polarization phenomena, Exchange current density, Polarization techniques to measure corrosion rates, Mixed potential theory, Activation and diffusion controlled mixed electrodes.	9
3	Methods of corrosion prevention and control, Design, coatings and inhibition, Cathodic protection, Stray current corrosion, Passivity phenomena and development of corrosion resistant alloys, Anodic control.	9
4	Biological aspects of corrosion, Microbially Induced Corrosion (MIC), Principles, Types, environments and microbiology, Biofilms, Corrosion by aerobic and anaerobic bacteria, Depolarization theory, Case studies, Failure analyses, Prevention of MIC, Corrosion of medical implants, Biocorrosion of concrete.	9
5	Metallurgical properties influencing corrosion.	5

Suggested Books

S. No.	Name of Books/Authors/Publisher	Year of Publication /Reprint
1	Principles of Corrosion Engineering and Corrosion Control/ Z. Ahmad, A. Alfantazi/ Butterworth-Heinemann	2019

2	Corrosion Engineering: Principles and Solved Problems/ B.N. Popov/ Elsevier.	2015
3	Corrosion Engineering and Cathodic Protection Handbook/ V. Cicek/ John Wiley & Sons.	2017

1. Subject Code: **CH315** Course Title: **Plastic Technology**
2. Contact Hours: L: 03 T: 01 P: 00
3. Examination Duration (Hrs.): Theory: 03 Practical: 00
4. Relative Weight: CWS: 25 PRS: 00 MTE: 25 ETE: 50 PRE: 00
5. Credits: 04
6. Semester: ODD-V
7. Subject Area: DEC/GEC
8. Pre-requisite: NIL
9. Objective: To impart knowledge about industrial preparation, properties and application of polymers.
10. Course Outcomes: After completing this course, students would be able to

1. Explain the manufacturing of different commodity and Engineering plastic.
2. Categorize the polymers based on their properties.
3. Identify the applications of polymers based on their properties
4. Design new polymer material by applying knowledge of recent advance in polymer material.

11.Details of Course:

S. No.	Contents	Contact Hours
1	Commodity plastics: Manufacture, properties and applications of polyethylene, polypropylene, polyvinyl chloride polyacrylate, polymethyl methacrylate, polyvinyl acetate, polyvinyl alcohol.	14
2	Engineering plastics: Industrial preparation, properties and applications of polyethylene terephathalate, polybutylene terphthalate, polyamides, polycarbonate, polyacetal, polystyrene.	14
3	Thermosetting polymers: Preparation, properties and applications of phenol formaldehyde, unsaturated polyester, urea and melamine formaldehyde, epoxy resins.	10
4	Recent advancements in polymeric materials.	4

Suggested Books

S. No.	Name of Books/Authors/Publisher	Year of Publication /Reprint
	Brydson's Plastics Materials/ M. Gilbert/ Elsevier	2016

1	Plastics Technology: Introduction and Fundamentals/ C. Bonten/ Carl Hanser Verlag GmbH & Company KG	2019
2	Plastics Technology Handbook, Fourth Edition/ M. Chanda, S.K. Roy/ CRC Press.	2006

1. Subject Code: **CH317** Course Title: **Resin Technology**
2. Contact Hours: L: 03 T: 01 P: 00
3. Examination Duration (Hrs.): Theory: 03 Practical: 00
4. Relative Weight: CWS: 25 PRS: 00 MTE: 25 ETE: 50 PRE: 00
5. Credits: 04
6. Semester: ODD-V
7. Subject Area: DEC/GEC
8. Pre-requisite: NIL
9. Objective: To aware students about resin, their classification and applications.
10. Course Outcomes: After completing this course, students would be able to

1. Identify the structure and properties correlation of the natural and synthetic resin,
2. Identify and solve the problems related to manufacturing process of synthetic resin
3. Design the new resin and their processing methods for application in different disciplines

11. Details of Course

S. No.	Contents	Contact Hours
1	Resins and resinous state, Classification, Natural and synthetic resins, Composition, Purification and Uses, Modification of natural resins.	7
2	Polyester Resins: Curing of resins, Catalysts and Accelerators, Water reducible polyesters, High solid polyesters/ polyesters for powder coatings, Moulding compositions, DMC, SMC, fibre and film forming compositions.	8
3	Phenolic Resins: Basic components, Theory of resinification, Reaction mechanism, Effect of ratio of reacting components and pH on reaction mechanism, Novolacs and Resol, Curing and moulding, Applications of phenolic resins.	9
4	Amino Resins: Synthesis and properties of UF and MF resins, Theory of resinification, Reaction mechanism, Effect of pH on the reaction mechanism, s, Curing and moulding, Applications of amino resins.	9
5	Alkyd Resins: Functionality concepts, Use of polyfunctional acids and alcohols, phthalic acid resins, Manufacturing, Types of modifications and properties of modified alkyd resins, Applications of alkyd resins.	9

Suggested Books

S. No.	Name of Books/Authors/Publisher	Year of Publication /Reprint
1	The Complete Book on Adhesives, Glues & Resins Technology/ NPCS Board of Consultants & Engineers	2017
2	Epoxy Resins Technology Handbook/ H. Panda/ Asia Pacific Business Press Inc.	2019
3	Synthetic Resins Technology Handbook/ NIIR Board of Consultants & Engineers	2005
4	The Complete Book on Adhesives, Glues & Resins Technology/ NPCS Board of Consultants & Engineers	2007

1. Subject Code: **CH319** Course Title: **Rubber Technology**
2. Contact Hours: L: 03 T: 01 P: 00
3. Examination Duration (Hrs.): Theory: 03 Practical: 00
4. Relative Weight: CWS: 25 PRS: 00 MTE: 25 ETE: 50 PRE: 00
5. Credits: 04
6. Semester: ODD-V
7. Subject Area: DEC/GEC
8. Pre-requisite: NIL
9. Objective: To impart knowledge about rubber technology and their applications.
10. Course Outcomes: After completing this course, students would be able to

    1. Differentiate natural rubber, synthetic rubber - their preparation, properties and applications.
    2. Explain basics of rubber compounding and vulcanization and rubber products manufacturing.
    3. Co-relate the concepts of flexible polymer chains and its influence on properties of rubber.
    4. Describe the chemistry, manufacturing technology, compounding, vulcanization, properties and applications of different elastomers.
    5. Identify suitable rubber materials for various engineering applications.

11. Details of Course:

S. No.	**Contents**	**Contact Hours**
1	Introduction to rubber, elasticity of rubber chain, elasticity of a network, thermodynamics of rubber elasticity, morphology of rubber, structure property relationship in rubbers, non elastomeric properties, chemical reactivity solution properties.	8
2	Natural Rubber: Source, Chemical Formula, Molecular weight distribution, concept of Sol, Gel, Microgel and Macrogel. Natural rubber from latex, field latex composition, methods of concentration and stabilization of latex, effect of electrolyte and protein, processing of latex into sheet and pale crepe rubber.	8

3	Synthetic Rubbers: preparation, properties and application of styrene butadiene, polybutadiene, polyisoprene, ethylene propylene, thiokol, butyl, nitrile, silicon and polyurethane rubber.	8
4	Rubber additives and compounding: Pre-vulcanized latex, Vulcanizing agents, vulcanization theory, activators, accelerator, fillers, softeners, antioxidants, peptizers, retarders, stiffeners, flame retardants, colors and pigments, tackifying agents, blowing agents, bonding agents, compound development and compounding of rubbers, Principle and working of Mooney viscometer.	9
5	Manufacture of latex products by impregnation and spreading process, casting impregnation, dipping process, latex coatings, latex cement and adhesives, latex thread and coir, latex foam. Manufacture of rubber products. Manufacture of rubber products as Tubes, Hoses, Footwear.	9

Suggested Books

S. No.	Name of Books/Authors/Publisher	Year of Publication/Reprint
1	The Science & Technology of Rubber/ Erman & Ronald/ Academic Press	2013
2	Hand Book of Rubber Formulations: Rubber Technology/ S.P. Athavale/ Notion Press.	2018
3	Rubber Technology Vol. 1 &Vol. 2/ S.C. Bhatia, A. Goel/ Woodhead Publishing India Pvt Limited	2019
4	Rubber Compounding: Chemistry and Applications/ Rodgers/ CRC Press	2015

1. Subject Code: **CH321** Course Title: **Numerical Methods in Chemical Engineering**
2. Contact Hours: L: 03 T: 01 P: 00
3. Examination Duration (Hrs.): Theory: 03 Practical: 00
4. Relative Weight: CWS: 25 PRS: 00 MTE: 25 ETE: 50 PRE: 00
5. Credits: 04
6. Semester: ODD-V
7. Subject Area: DEC/GEC
8. Pre-requisite: NIL
9. Objective: To enable the students to learn errors, equations, curve-fittings and numerical solutions.
10. Course Outcomes: After completing this course, Student should be able to

    1. Apply different numerical methods in chemical engineering problems.
    2. Select the suitable numerical method to solve a given problem
    3. Quantify the errors in the solutions
    4. Develop the MATLAB code to solve the given numerical problem.

11. Details of Course

S. No.	Contents	Contact Hours
1	Error Analysis: Taylor series expansion, Truncation error. Round-off error vs. Chopping-off error. Propagation of Error.	8
2	Solution of simultaneous linear equations: Cramer's rule, Gauss elimination Method, Gauss-Jordon Method, and LU Decomposition, Gauss-Seidel and Relaxation Methods, Iterative method - Jacobi iteration, Application in steady-state solution of isothermal CSTR.	8
3	Solution of Non-linear Algebraic equations: Bisection method, Newton-Raphson method, Secant method, Modified Newton-Raphson method for multiple roots - Application in thermodynamic property calculation, bubble point and dew point calculation. Finding of multiple roots of a polynomial, Solution of a set of non-linear equations - Newton's method, Multivariable Newton-Raphson Technique. Jacobian matrix, characteristics equations and stability.	10
4	Curve-fitting: Least-square method for straight line and polynomial (Linear Regression), Newton's interpolation formulae (equal intervals), Divided Difference (Unequal intervals), differentiation formulae, Integration formulae (Trapezoidal, Simpson's 1/3 and 3/8 rules), Extrapolation Technique of Richardson and Gaunt.	8
5	Numerical Solution of ODE: Initial value problems using Finite difference Techniques; Runge-Kutta methods, Step-size control; Solution of a set of ODEs; Application in chemical and bio-chemical reactions; Stability analysis.	8

Suggested Books

S. No.	Name of Books/Authors/Publisher	Year of Publication /Reprint
1	Introduction to Numerical Methods in Chemical Engineering, Second Edition/ P. AHUJA/ PHI Learning Pvt. Ltd.	2019
2	MATLAB Numerical Methods with Chemical Engineering Applications/ Kamal I. M. Al-Malah/ McGraw Hill	2013
3	Numerical Methods and Modeling for Chemical Engineers/ M.E. Davis/ Courier Corporation	2013
4	Numerical Methods with Chemical Engineering Applications/ K.D. Dorfman, P. Daoutidis/ Cambridge University Press.	2017

1. Subject Code: **CH323** Course Title: **Biomaterials**
2. Contact Hours: L: 03 T: 01 P: 00
3. Examination Duration (Hrs.): Theory: 03 Practical: 00
4. Relative Weight: CWS: 25 PRS: 00 MTE: 25 ETE: 50 PRE: 00
5. Credits: 04
6. Semester: ODD-V
7. Subject Area: DEC/GEC

8. Pre-requisite: NIL

9. Objective: To enable the students to learn biomaterials, polymeric implant materials and bioceramics.

10. Course Outcomes: After completing this course, students would be able to

1. Identify different biomaterials and classify them based on their properties.
2. Identify and analyse the biological responses on foreign materials
3. Explain the crucial properties of different implant materials.
4. Explain the specific characteristics, testing of metallic, polymeric and ceramic implant materials.
5. Develop or Select the proper implant material for a given applications.
6. Perform and evaluate the performance of different implant materials.

11. Details of Course

S. No.	Contents	Contact Hours
1	Biocompatibility, Biomaterials and their requirements, Classification, Effects of physiological fluid on the properties of biomaterials. Biological responses. Surface, physical and mechanical properties, Standards of implant materials.	8
2	Metallic implant materials: Alloys, Importance of corrosion cracking, Host tissue reaction, Importance of passive films for tissue adhesion, Hard tissue replacement implant, Soft tissue replacement implants.	9
3	Polymeric implant materials: Thermoplastics, Thermosetting, biopolymers and biodegradable polymers for implant, Properties of polymeric materials for implant, Controlled release systems, Synthetic polymeric membranes and their biological applications.	9
4	Concepts of bioceramics, Importance of wear resistance and low fracture toughness, Host tissue reactions, Importance of interfacial tissue reaction, Mechanics of improvement of properties by incorporating different elements, Composite theory of fiber reinforcement, Polymers filled with osteogenic fillers, Host tissue reactions.	8
5	Blood and tissue compatibility, Toxicity tests, Acute and chronic toxicity studies, Sensitization, Carcinogenicity, Mutagenicity and related tests. In vitro mechanical testing, Corrosion studies, In vivo testing, Biological performance of implants.	8

Suggested Books

S. No.	Name of Books/Authors/Publisher	Year of Publication /Reprint

1	Biomaterials: Physics and Chemistry/ R. Pignatello, T. Musumeci/ BoD – Books	2018
2	Biomaterials: Principles and Practices/ J.Y. Wong, J.D. Bronzino, D.R. Peterson/ CRC Press.	2012
3	Foundations of Biomaterials Engineering/ M.C. Tanzi, S. Farè, G. Candiani/ Academic Press.	2019

Departmental Elective Courses

6th Semester

Elective III and Elective IV

1. Subject Code: **CH308** Course Title: **Food Technology**
2. Contact Hours: L: 03 T: 01 P: 00
3. Examination Duration (Hrs.): Theory: 03 Practical: 00
4. Relative Weight: CWS: 25 PRS: 00 MTE: 25 ETE: 50 PRE: 00
5. Credits: 04
6. Semester: EVEN-VI
7. Subject Area: DEC/GEC
8. Pre-requisite: NIL
9. Objective: To make student aware about the food chemistry and applications of polymer in food packaging.
10. Course Outcomes: After completing this course, students would be able to

1. Explain the basics of food chemistry, Nutritive value of foods, Antioxidants, Flavouring agents, Food Analysis, Food additives.
2. Explain the concepts of microbiology and fermentation used in food technology.
3. Develop and design various food processing technics based on the knowledge of food chemistry, microbiology and fermentations.
4. Characterize the food based of their nutritive value, intoxicants present, rate of spoilage, and chemical present by various test methods.
5. Describe the requirements of food storage systems.
6. Design and developed food storage systems based on specific requirements.

11. Details of Course

S. No.	Contents	Contact Hours
1	Food chemistry: Composition of foods, Water relationships in food, chemistry of carbohydrates, proteins, amino acids, lipids, vitamins and their functions, Bioavailability and stability of nutrients, Nutritive value of foods, Antioxidants, Flavoring agents, Food Analysis, Food additives.	8
2	Food Microbiology: Microorganisms in foods, Factors that influence the development of microbes in food, Biotechnological improvements, Microbial growth pattern, Spoilage and chemical changes of food, Food borne intoxicants, infections and mycotoxins, Newer methods of food processing.	9
3	Fermentation products: Production of dairy products, Manufacture of milk products, Fermented foods and vegetables, Distilled beverages: Alcohol, wine, brandy and beer.	8

4	Food preservation and storage: Principles of food preservation; Physical, chemical and biological methods, Food preservation with low and high temperatures, drying, Indicator and Food-borne Pathogens.	9
5	Food packaging: Packaging and canning of foods, Active and intelligent packaging, Antimicrobial food packaging, Non-migratory bioactive polymers in food packaging, Plastics for food packaging.	8

Suggested Books

S. No.	Name of Books/Authors/Publisher	Year of Publication /Reprint
1	Objective Food Science & Technology, 3rd Ed./ D. Mudgil, S.B. Mudgil/ Scientific Publishers	2019
2	Introduction to Food Science and Technology/ G.F. Stewart, M.A. Amerine/ Elsevier	2012
4	Food processing and preservation/ Sivashankar/ Prentice – Hall of India Pvt.	2002
5	Food-borne Pathogens/ A.M. Emerging/ Woodhead Publ.	2006

1. Subject Code: **CH310** Course Title: **Paint Technology**
2. Contact Hours: L: 03 T: 01 P: 00
3. Examination Duration (Hrs.): Theory: 03 Practical: 00
4. Relative Weight: CWS: 25 PRS: 00 MTE: 25 ETE: 50 PRE: 00
5. Credits: 04
6. Semester: EVEN-VI
7. Subject Area: DEC/GEC
8. Pre-requisite: NIL
9. Objective: To familiarize the students with paint, its coating properties and environmental impact.
10. Course Outcomes: After completing this course, students would be able to

1. Explain technical aspect of paint technology, properties of paints, varnishes and pigments, their classifications and applications
2. Synthesise different types of inorganic and organic pigments, dyes and paints based on desired properties.
3. Perform the various testing of dyes, pigments and paints to characterize them based on desired properties.
4. Develop pigments or dyes to create special effects such as pearlescent, nacreous, phosphorescent, fluorescent and luminescent, IR reflecting pigments.
5. Use and apply colour index name and number, and colour coding systems.
6. Perform weathering test and developed weather resistant pigments and paints.

11. Details of Course

S. No.	Contents	Contact Hours
1	Introduction to Surface coatings, Classification, Paints, Varnishes, Lacquer, Pigment, Extender, Composition of surface coatings, Global scenario and future prospective of Indian Paint Industry, Aesthetics and saftey standards.	8
2	Inorganic pigments and extenders, Synthesis, micronisation and surface treatment of pigments, Source, manufacture, properties and uses of extenders, pigments such as carbonates, Silicates, Sulphates and Oxides; Extender mixtures, Calcined Pigments and Extenders, Nano pigments and extenders.	8
3	Organic pigments and dyestuffs: Dyes and pigments, Chemical structures and their colour imparting behaviours, Auxochromes and chromophores, Influence of physical factors; colour psychology. Natural organic pigments, Coaltar distillation products, Mordants and precipitants, Bases for colour striking and lakes, miscellaneous salts and chemicals. Chemical reactions for synthesis of various dyes and pigments, Synthetic organic pigments: Azo pigments, Basic and acid dyes pigments, Miscellaneous organic pigments.	12
4	Special effect pigments like pearlescent, nacreous, phosphorescent, fluorescent and luminescent, IR reflecting pigments, thermochromic pigments, polymeric pigments, invisible pigments, High performance Pigments & dyes, Comparison of organic and inorganic pigments, Colour index name and number,Colour coding systems.	7
5	Environmental resistance and ageing properties of paints and coatings, natural & accelerated outdoor weathering tests, weather-o-meter, Evaluation of water based paints, Exterior test protocol, In-can and dry film preservation, Hygiene surfaces.	7

Suggested Books

S. No.	Name of Books/Authors/Publisher	Year of Publication /Reprint
1	Paint Technology handbook/ R. Talbert/ CRC Press	2008
2	Introduction to Paint Chemistry and Principles of Paint Technology/ G. P. A. Turner/ Springer	2014
3	Paints Pigments Varnishes and Enamels Technology Handbook with Process and Formulations/ NIIR Board	2016

1. Subject Code: **CH312** Course Title: **Polymer Processing Techniques**
2. Contact Hours: L: 03 T: 00 P: 02
3. Examination Duration (Hrs.): Theory: 03 Practical: 00
4. Relative Weight: CWS: 15 PRS: 15 MTE: 30 ETE: 40 PRE: 00
5. Credits: 04
6. Semester: EVEN-VI
7. Subject Area: DEC/GEC

8. Pre-requisite: NIL

9. Objective: To impart knowledge of polymer processing to the students

10. Course Outcomes: After completing this course, students would be able to

1. The students shall able to describe the working principle of the Polymer Processing Machines
2. The students shall able to identify and solve the complex engineering problems related to polymer processing machines and process.
3. The students can use the process parameter knowledge of various machine to carry out new process design research for different polymers
4. The students shall create and apply appropriate polymer processing technique to give engineering solutions for new polymers.

11. Details of Course:

S. No.	Contents	Contact Hours
1	Plastics additives and compounding: Antioxidants, metal deactivators, stabilizers, plasticizers, lubricants, processing aids, impact modifiers, fillers and reinforcements, colorants, flame retardants, anti-static agents, blowing agents, nucleating agents, compound development and compounding of plastics.	7
2	Principle of mixing and mixers: Introduction, mechanism of mixing, practical mixing variables. Types of mixers: roll mills, internal batch mixers, sigma mixers, high speed mixer, blending, kneading and granulating equipment.	5
3	Extrusion: Principle of extrusion, Screw design, Qualitative and quantitative aspects of mechanism of screw extrusion and effects of screw and die design, Extrusion Dies: Constructional features of dies, equipment for extrusion, tubes, rods, pipes, blown film, cast film, Oriented film, Sheet extrusion, coating and lamination; processing parameters; Trouble shooting of processing techniques; twin screw extruder, types of twin screw extruder; process parameters in twin screw extruder. Construction features of vent Extruder	9
4	Compression molding machine: types, principles of operations, molding cycle, meaning of terms bulk factor and flow properties as applied to molding materials, the interplay of heat, pressure, friction, catalysts etc. for thermosetting materials; trouble shooting	6
5	Injection molding machine-machine description study, types and limitations, working principles, process variables, trouble shootings, gas assisted injection molding, structural foam molding, reaction injection molding process, their industrial applications; trouble shooting	9

6	Blow molding process, principles and description of blow mold, extrusion &injection stretch blow molding, parison control, trouble shooting. Miscellaneous processing methods: casting, rotational molding, decoration of polymers, working principles of calendaring and thermoforming process	6

Suggested Books

S. No.	Name of Books/Authors/Publisher	Year of Publication/Reprint
1	Handbook of Plastic Processes/ Harper/ Wiley Interscience	2006
2	Principles of Polymer Processing/ Tadmor & Gogos/ Wiley Interscience	2013
3	Plastics Engineering/ R J Crawford/ Butterworths	2013
4	Polymer Extrusion/ Chris Rauwendaal/ Carl Hanser Verlag GmbH & Company KG,	2019
5	Plastic Materials/ J A Brydson/ Butterworth-Heinemann	2007

1. Subject Code: **CH314** Course Title: **Fertilizer Technology**
2. Contact Hours: L: 03 T: 01 P: 00
3. Examination Duration (Hrs.): Theory: 03 Practical: 00
4. Relative Weight: CWS: 25 PRS: 00 MTE: 25 ETE: 50 PRE: 00
5. Credits: 04
6. Semester: EVEN-VI
7. Subject Area: DEC/GEC
8. Pre-requisite: NIL
9. Objective: To impart knowledge about the properties, applications and packaging of fertilizers.
10. Course Outcomes: After completing this course, students would be able to

    1. Explain the basic concepts of fertilizer technology, classification of fertilizer, their importance and working mechanism.
    2. Describe the productions of chemical fertilizers at industrial scale by using flowcharts.
    3. Perform basic material and energy balance of fertilizer production to predict the cost of fertilizers.
    4. Analyse the economy and markets of row materials and final products in fertilizer industry.
    5. Identify various special types of fertilizers and their requirements.
    6. Describe the use of polymers in fertilizer industry.

11. Details of Course

S. No.	Contents	Contact Hours
1	Chemical fertilizers and organic manures; types of chemical fertilizers; Methods of production of nitrogenous fertilizer-ammonium sulphate, nitrate, urea and calcium ammonium nitrate; ammonium chloride and their methods of production, characteristics and specifications, storage and handling.	9
2	Phosphatic fertilisers, phosphate rock, sulphur; pyrites etc., processes for the production of sulphuric and phosphoric acids; phosphates fertilizers - ground rock phosphate; bone meal-single superphosphate, triple superphosphate, triple superphosphate, thermal phosphates and their methods of production, characteristics and specifications.	9
3	Complex and NPK fertilisers: Methods of production of ammonium phosphates, nitrophosphates, urea and various grades of NPK fertilizers.	8
4	Miscellaneous fertilisers: Mixed fertilizers and granulated mixtures; biofertilizers, Nutrients, Secondary and micro nutrients; Fluid fertilizers, Controlled release fertilizers.	9
5	Applications of polymers in fertilizer industry	7

Suggested Books

S. No.	Name of Books/Authors/Publisher	Year of Publication /Reprint
1	Fertilizer Technology and Management/ B. Mishra/ I.K. International Publishing House Pvt. Limited	2012
2	Manual of Fertilizer Processing/ Nielsson/ Routledge.	2018
3	The Chemistry and Technology of Fertilizers/ Sauchelli/ ACS monograph No.148, Reinhold Publishing Corp. New York.	2004
4	Organic Fertilizers: From Basic Concepts to Applied Outcomes/ M. Larramendy, S. Soloneski/ BoD – Books on Demand.	2016

1. Subject Code: **CH316** Course Title: **Coatings and Adhesives**
2. Contact Hours: L: 03 T: 01 P: 00
3. Examination Duration (Hrs.): Theory: 03 Practical: 00
4. Relative Weight: CWS: 25 PRS: 00 MTE: 25 ETE: 50 PRE: 00
5. Credits: 04
6. Semester: EVEN-VI
7. Subject Area: DEC/GEC
8. Pre-requisite: NIL
9. Objective: To impart knowledge about polymeric coatings, adhesives and their applications.
10. Course Outcomes: After completing this course, students would be able to

1. Understand the fundamentals of basic coating processes and the mechanism behind them.
2. Understand the film forming mechanism and the basic requirements for good film formation.
3. Apply their knowledge of different types of coatings for making a selection for the required application.
4. Understand the fundamentals of adhesion, prerequisites for a good bond formation and selection of adhesive for the required application.
5. Apply their knowledge of the various adhesives for the required application.

11. Details of Course

S. No.	Contents	Contact Hours
1	Introduction & classification of adhesives, mechanism of adhesion of polymeric coatings on various substrates, chemically reactive adhesives	10
2	Preparation of adhesives, animal glue, protein adhesives, starch adhesives, synthetic resin adhesives, rubber based adhesives, cellulose & silicate adhesives, industrial application of adhesives.	10
3	Solvent based polymeric coatings, Water based polymeric coatings, UV and EB curable coatings, 100% convertible coatings, Selection criteria of coating for various substrates.	10
4	Coating techniques for various substrates	8
5	Health hazards and environmental aspects of coatings during manufacturing and applications.	4

Suggested Books

S. No.	Name of Books/Authors/Publisher	Year of Publication /Reprint
1	Coatings Technology Handbook, 3rd Ed/ Tracton/ CRC Press	2005
2	Organic Coatings: Science and Technology, 3rd Ed/ Wicks et al/ Wiley	2007
3	Green Chemistry for Surface Coatings, Inks and Adhesives/ R. Hoefer, A. Matharu, Z. Zhang/ Royal Society of Chemistry	2019
4	Hand Book of Pressure Sensitive Adhesives and Coatings/ S.P. Athavale/ Notion Press.	2018

1. Subject Code: **CH318** Course Title: **Petrochemical Engineering**
2. Contact Hours: L: 03 T: 01 P: 00
3. Examination Duration (Hrs.): Theory: 03 Practical: 00
4. Relative Weight: CWS: 25 PRS: 00 MTE: 25 ETE: 50 PRE: 00
5. Credits: 04
6. Semester: EVEN-VI
7. Subject Area: DEC/GEC
8. Pre-requisite: NIL
9. Objective: To make student aware about the theory, principle and applications of membrane.
10. Course Outcomes: After completing this course, students would be able to

1. Understand the production of organic intermediate products in petrochemical industry.
2. Learn its importance for the growth of industrial sectors.
3. Innovation of newer applications and products with focus on sustainable development.
4. Understand its importance for the growth of agricultural sectors.
5. Learn the use of new technologies to create most of the everyday items.

11. Details of Course

S. No.	Contents	Contact Hours
1	Petrochemicals Industry Overview, Formaldehyde and Chloromethane**,** Hydrocarbon Steam Cracking for Petrochemicals, Vinyl Chloride from Ethylene, Ethylene oxide and Ethanolamines	10
2	Isopropanol and Acetone from Propylene, Cumene and Acrylonitrile from Propylene, Isoprene and Oxoprocessing, Butadiene and Benzene Manufacture, Phenol from Cumene and Toluene, Phenol from Benzene	8
3	Styrene and Pthalic Anhydride Production, Manufacture of Maleic Anhydride and DDT, Manufacture of Phenol Form aldehyde, Viscose Rayon and Nylon	8
4	Natural gas processing and value addition, olefin production technologies, Novel operations used in petrochemical Industries.	8
5	Chemical recovery from black liquor, Manufacture of Ethanol from Molasses, Biofuel, bioethanol, biodiesel, Biofuels from lignocellulose biomass	8

Suggested Books

S. No.	Name of Books/Authors/Publisher	Year of Publication /Reprint
1	Fundamentals of Petroleum and Petrochemical Engineering/ U.R. Chaudhuri/ CRC Press	2011
	Introduction to Petroleum Engineering/ John R. Fanchi, Richard L. Christiansen/ John Wiley & Sons.	2016
2	Handbook of Petroleum Refining Processes; 3rd Ed/ Meyers/ McGraw-Hill	2004

4	Petroleum Refining Technology/ Indra Deo Mall/ CBS	2015

1. Subject Code: **CH320** Course Title: **Packaging Technology**
2. Contact Hours: L: 03 T: 01 P: 00
3. Examination Duration (Hrs.): Theory: 03 Practical: 00
4. Relative Weight: CWS: 25 PRS: 00 MTE: 25 ETE: 50 PRE: 00
5. Credits: 04
6. Semester: EVEN-VI
7. Subject Area: DEC/GEC
8. Pre-requisite: NIL
9. Objective: To familiarize students with packaging materials, their testing and quality control.
10. Course Outcomes: After completing this course, students would be able to

1. Explain the effectively and clearly the important concepts of Packaging Technology.
2. Compare and Characterize different types of Packaging Materials.
3. To use technical skills for initiation and further development of carrier in packaging industry.
4. Solve the problems of Packaging Industries.
5. Minimizing the adverse impact of Packaging Materials on the eco- system for the welfare of society.
6. Deliver the learning of the Packaging Technology to society and academic institutions.

11. Details of Course

S. No.	Contents	Contact Hours
1	Introduction: Packaging in production and marketing; Packaging characteristics, Physical properties; Mechanism of spoilage, degradation, corrosion & their prevention; Compatibility: permissible plasticizers and their migration to food products; Package design.	8
2	Packaging Materials: Papers and speciality papers, Cellulosic films and laminates; Plastics in packaging: PE, PP, PS, PVC, PVDC, Nylon, Polyester and their combinations; Expanded PE, PS and bubble films; Glass containers, ampoules and vials; Composite containers, drums and paper tubes; Aluminium foils, laminates and coating; Single layer and multilayer polymer packaging.	8
3	Ancillary materials: Adhesives, Adhesive tapes; Cushioning materials and properties, Reinforcements; Stitching methods; Seals and enclosures; Lining compounds and lacquers; Labels and instant labeling; bar coding	9
4	Graphic design; Printing techniques, Printing inks and print evaluations.	8
5	Testing, Standards and Quality control: Mechanical testing, resistance to light, insect and mould. Barrier testing for air, oxygen etc., shelf life, Seal tests. Standards- basic concepts, standards for rigid and non rigid	9

	and ancillary materials, standards for export packages, ISO 9000 and implications. Eco packaging and regulations.	

Suggested Books

S. No.	Name of Books/Authors/Publisher	Year of Publication /Reprint
1	Materials for Advanced Packaging/ Lu/ Springer	2009
2	Packaging Technology: Fundamentals, Materials and Processes/ A. Emblem/ Elsevier	2012
3	Plastic Packaging Materials for Food: Barrier Function, Mass Transport, Quality Assurance, and Legislation/ Piringer & Baner/ Wiley	2008
4	Fundamentals of Packaging Technology/ S. Natarajan, M. Govindarajan, B. Kumar/ PHI Learning Pvt. Ltd.	2014

1. Subject Code: **CH422** Course Title: **Tyre Technology**
2. Contact Hours: L: 03 T: 01 P: 00
3. Examination Duration (Hrs.): Theory: 03 Practical: 00
4. Relative Weight: CWS: 25 PRS: 00 MTE: 25 ETE: 50 PRE: 00
5. Credits: 04
6. Semester: ODD-VII
7. Subject Area: DEC/GEC
8. Pre-requisite: NIL
9. Objective: To familiarize the students with tyre, its design and manufacturing.
10. Course Outcomes: After completing this course, students would be able to

    1. Explain basic concepts of tyre technology such as different components of tyre, their function, desire properties, material used etc.
    2. Design different components of tyre based on desired properties.
    3. Identify and develop the different compounding/composite materials for different components of tyre based on specific properties.
    4. Describe the manufacturing process of tyre and optimize the main operational parameters.
    5. Perform the destructive and non-destructive testing of tyres.

11. Details of Course

S. No.	**Contents**	**Contact Hours**
1	Importance of tyres, Functions and desirable properties of tyres, Classification of tyres, Sizing & Designation, Tyre components, Problems associated with tyres and their remedies.	9

2	Aspects of tyre design, Analysis of motive forces, Types of bonding, Set of service conditions, Tyre size requirements, Safety requirements, Tread design, Role of foot print area and factors affecting tread life, Various types of tread pattern, Carcass design, Role of various fibres used in carcass, Estimation of number of plies, Bead design, Various configurations of wires in bead assembly.	10
3	Compound design, Role of various mixing ingredients, various recipes, Compound mixing, Mixing equipments.	7
4	Extrusion of components, Tyre and wire cord manufacture, Component preparation, Green tyre building, Pre- and post-curing operations/treatments.	8
5	Tyre Testing and evaluation, Carcass strength, Resistance to bead unseating, Machine simulation tests, Indoor laboratory testing, Field test on road, Proving grounds, Latest testing techniques.	8

Suggested Books

S. No.	Name of Books/Authors/Publisher	Year of Publication /Reprint
1	Tyre Technology 3rd Ed/ T. French/ Adam Hilger	2010
2	Technology Of Rubber And Rubber Goods Industries/ Eiri/ Engineers India Research In.	2007
3	Hand Book of Rubber Formulations: Rubber Technology/ S.P. Athavale/ Notion Press.	2018
4	Rubber Technology Vol. 1 &Vol. 2/ S.C. Bhatia, A. Goel/ Woodhead Publishing India Pvt Limited	2019
5.	Technology of Rubber And Rubber Goods Industries/ Eiri Consultants and Engineers/Engineers India Research In./ Sudhir Gupta	2005

1. Subject Code: **CH324** Course Title: **Heat Exchangers**
2. Contact Hours: L: 03 T: 01 P: 00
3. Examination Duration (Hrs.): Theory: 03 Practical: 00
4. Relative Weight: CWS: 25 PRS: 00 MTE: 25 ETE: 50 PRE: 00
5. Credits: 04
6. Semester: EVEN-VI
7. Subject Area: DEC/GEC
8. Pre-requisite: NIL
9. Objective: To provide the knowledge of heat exchanger application design and simulations.
10. Course Outcomes: After completing this course, students would be able to

1. Explain the fundamentals of basis Heat exchange and their equations.

2. Classified the materials on their thermal conductivity and able to solve the problems related to the heat exchanges.

3. Apply the concepts convection along with the conduction to solve the industrial heat exchange problems involving heat exchanger and condensers.

4. Describe the phenomena of heat exchange between bodies by radiation in absence of any media.

5. Design of different heat exchangers and other process equipment involving heat transfer.

11. Details of Course

S. No.	Contents	Contact Hours
1	Types of heat exchangers and their applications. Flow arrangements and temperature distributions in transfer type of heat exchangers. Overall heat transfer coefficient;- Clean overall heat transfer coefficient, dirt factor dirt overall heat transfer coefficient, dirt factors for various process services. Basic design equation. Mean temperature difference Concept: - LMTD for parallel flow and counter flow arrangement, correction factor for LMTD for cross flow and multi –pass heat exchangers.	8
2	Shell and Tube Heat Exchangers: Constructional features. Applications. Effectiveness-NTU method for heat exchanger design/ analysis. Rating and sizing problem. Correlations for tube side pressure drop and heat transfer coefficients. Pressure drop and heat transfer coefficient correlations for shell side flow.	8
3	Effect of By – Pass and Leakage Calculation Procedure for Shell and Tube Heat Exchanger: Heat balance equations: LMTD: reference temperature calculations: evaluation of fluid properties: flow assignments: tube side flow area calculations; viscosity correction factor, shell side equivalent diameter, calculation of shell side heat transfer coefficient, evaluation for wall temperature, evaluation of overall heat transfer coefficient, Calculation of surface area. Calculations of tube side and shell side pressure drops.	10
4	Double Pipe Heat Exchangers: Constructional features. Applications. Design parameters :- tube side and shell side film coefficients cut and twist factor, fin efficiency, overall heat transfer coefficient, mean temperature difference, available surface area, fin geometry fin height, number of fins, tube side and shell side pressure drop. Calculation procedure for the design/analysis of double pipe heat exchanger.	8
5	Compact Heat Exchangers: Introduction; definition of Geometric Terms: plate fin surface geometries and surface performance data; correlation of heat transfer and friction data; Goodness factor	8

	comparisons; specification of rating and sizing problems; calculation procedure for a rating problem.	

Suggested Books

S. No.	Name of Books/Authors/Publisher	Year of Publication /Reprint
1	Heat Exchangers: Design, Experiment and Simulation/ S.M.S. Murshed, M.M. Lopes/ BoD – Books on Demand	2017
2	Heat Exchanger Design Handbook, Second Edition/ K. Thulukkanam/ CRC Press.	2013
3	Fundamentals of Heat Exchanger Design/ R.K. Shah, D.P. Sekulic/ John Wiley & Sons	2003

Departmental Elective Courses

7th Semester

Elective V and Elective VI

1. Subject Code: **CH405** Course Title: **Fibre Technology**
2. Contact Hours: L: 03 T: 00 P: 02
3. Examination Duration (Hrs.): Theory: 03 Practical: 00
4. Relative Weight: CWS: 15 PRS: 15 MTE: 30 ETE: 40 PRE: 00
5. Credits: 04
6. Semester: ODD-VII
7. Subject Area: DEC/GEC
8. Pre-requisite: NIL
9. Objective: To impart knowledge about fibre, their spinning and preparation to the students.

10. Course Outcomes: After completing this course, students would be able to

1. Identify the structure and properties correlation of the natural and manufactured fibers to predict the properties of news fibers
2. Identify and solve the problems related manufacturing process of synthetic fibers
3. Design the new fibers and their processing methods for application in different disciplines
4. Design and develop application of colorant on new fiber by understanding the fundamentals of coloration of fibers.
5. Identify strategies for recycling of by products and textile waste materials.

11. Details of Course:

S. No.	Contents	Contact Hours
1	Introduction to fibres and basic terminology, Characteristics of fibre forming polymers, Classification of fibres, Properties and structure of natural fibres.	9
2	Principles of fibre spinning, Melt spinning, Solution spinning, Gel spinning, Electro-spinning, Effect of process parameters of each spinning techniques on structure and properties of fibres.	8
3	Post spinning operations, Principles and effects on properties of fibres, Drawing, Heat setting, Spin finish, Texturing, Top to tow converters.	8
4	Manufacturing, properties and uses of viscose rayon, acetate rayon, polyester, polyamide, polyacrylonitrile and polypropylene fibres.	8

5	Manufacturing, properties and uses of kevlar, nomex, polyurethane, high density polyethylene fibres, bicomponent fibers, hollow fibers.	9

Suggested Books

S. No.	Name of Books/Authors/Publisher	Year of Publication/Reprint
1	A Textbook of Fibre Science and Technology/ SP Mishra/ New Age Publication	2014
2	Fibre Materials for Advanced Technical Textiles/ T. Matsuo/ CRC Press.	2019
3	Manufactured Fibre Technology/ V.B. Gupta, V.K. Kothari/ Springer	2012

1. Subject Code: **CH407** Course Title: **Polymer Blends and Composites**

2. Contact Hours: L: 03 T: 01 P: 00
3. Examination Duration (Hrs.): Theory: 03 Practical: 00
4. Relative Weight: CWS: 25 PRS: 00 MTE: 25 ETE: 50 PRE: 00
5. Credits: 04
6. Semester: ODD-VII
7. Subject Area: DEC/GEC
8. Pre-requisite: NIL
9. Objective: To impart knowledge about the polymer, blends and composites to the students.
10. Course Outcomes: After completing this course, students would be able to

1. Explain the fundamentals of polymer blends, alloys and blending equipments along with the thermodynamic aspects, phase diagram and morphology of polymer blends.
2. Analyze and co-relate the basic issues involved in polymer blends, composites and nanocomposites and the compatibility of various systems of polymers.
3. Select the appropriate combination of polymers to have required synergistic property in the polymer blend.
4. Develop novel polymer blend and their nanocomposites to achieve synergistic properties.
5. Analyze and characterize the various properties of polymer blends & composites and will be capable to apply the knowledge to develop cost effective/ ecofriendly/ sustainable products.

11. Details of Course

S. No.	Contents	Contact Hours
1	Polymer blends classification, Principles of polymer compatibility, Different theories of predicting compatibility, Factors governing	10

	compatibility, Compatibilizers, Property achieved by blending, Methods of blending, Characterization of blends, Commercial polyblends and their properties, Morphology of blends and its determination.	
2	Introduction to rheology of polymer blends, Its relevance in processing, Rheology phase morphology relationships and their relevance.	8
3	Classification of composite, particulate and fibrous composite, Introduction to reinforcing material.	8
4	Properties of composites, Fabrication of continuous and short fiber composites and particulate composites, Mechanical and physical properties.	8
5	Environmental effect on composites, Test methods and applications of composites.	8

Suggested Books

S. No.	Name of Books/Authors/Publisher	Year of Publication /Reprint
1	Polymer Blends and Composites: Chemistry and Technology/ M.N. Subramanian/ John Wiley & Sons.	2017
2	Composite Materials: Science & Engineering/ Chawla/ Springer India	2012
3	Polymer Blends and Composites/ J.A. Manson/ Springer	2012
4	Polymer composites: From nano to macro scale/ Friedrich et al/ Springer	2005

1. Subject Code: **CH409** Course Title: **Plant Design and Engineering Economics**

2. Contact Hours: L: 03 T: 01 P: 00
3. Examination Duration (Hrs.): Theory: 03 Practical: 00
4. Relative Weight: CWS: 25 PRS: 00 MTE: 25 ETE: 50 PRE: 00
5. Credits: 04
6. Semester: ODD-VII
7. Subject Area: DEC/GEC
8. Pre-requisite: NIL
9. Objective: To make student aware about the basic of process design, plant location and layout and cost estimation.
10. Course Outcomes: After completing this course, students would be able to

1. Explain various technical aspects of process design such as process selection, selection of plant cite, feasibility survey, Optimization of design variables etc.

2. Describe the various elements of a plants layout including chemical process design, utility design, safety audits and requirements.
3. Explain the basic concepts of project scheduling.
4. Estimate the cost of a project by using cost estimation principles.
5. Apply various project economics principles to evaluate economic factors such as profitability, rate of return, pay out period etc. to evaluate risk associated with a projects.

11. Details of Course

S. No.	Contents	Contact Hours
1	Basis of Process Design: Steps in process development, selection of process, factors affecting process selection, Project organization, preliminary data collection, process engineering, Feasibility survey, importance of laboratory development to pilot plant, scale up methods, types flow sheet, selection of process equipment, development of process flow sheet from process information. Optimum Design and Design strategy: Basic principle of Optimum Design, general procedure for determining optimum conditions, Optimum production rate in plant.	11
2	Plant Location and Layout: Plant location and layout, factors affecting both planning and layouts, drawings of plant layout, plant elevation drawings and complex engineering flow sheet drawings; environment and safety clearances, Safety methods in plant equipment, problems in standardization and commissioning. Project scheduling, use of PERT/CPM methods. Project evaluation and assessment of project profitability.	11
3	Cost Estimation: Factors affecting investment and production costs, Capital investments – fixed investments and working capital. Cost indices. Estimating equipment costs by scaling 6/10 factor rule. Methods for estimation capital investment. Estimation of total product cost. Different costs involved in the total product for a typical chemical process plant.	10
4	Cash flow statement, discounted cash flow, pay-back period, breakeven analysis, introduction to market survey, Balance sheet and income statement, minimum economics plant capacity, technological obsolescence, need for expansion and diversification, concept to marginal additional investment, role of research and development, Indian chemical industry, current state and trends.	10

Suggested Books

S. No.	Name of Books/Authors/Publisher	Year of Publication /Reprint
1	Plant Design and Economics for Chemical Engineering/ Peters & Timmerhaus/ McGraw Hill	1991
2	Engineering Economics and Economic Design for Process Engineers/ T. Brown/ CRC Press.	2016

3	Chemical Engineering Design, 2nd Ed/ Sinnott, Elsevier	2012
4	Process Engineering Economics/ Couper/ CRC Press	2003

1. Subject Code: **CH411** Course Title: **Advance Mass Transfer Operations**
2. Contact Hours: L: 03 T: 01 P: 00
3. Examination Duration (Hrs.): Theory: 03 Practical: 00
4. Relative Weight: CWS: 25 PRS: 00 MTE: 25 ETE: 50 PRE: 00
5. Credits: 04
6. Semester: ODD-VII
7. Subject Area: DEC/GEC
8. Pre-requisite: NIL
9. Objective: To impart knowledge about advance mass transport phenomena.
10. Course Outcomes: After completing this course, students would be able to

1. Explain various technical aspects of mass transfer.
2. Explain basic concepts of mass transfer operations.
3. Understand the newer applications associated with mass transfer operations.
4. Learn the use of these operations in the growth of industrial sectors.
5. Understand the principles of multicomponent gas absorption.

11. Details of Course:

S. No.	Contents	Contact Hours
1	Interphase mass transfer for multicomponent fluids in laminar and turbulent flows, Interfacial turbulence and Marangoni effects	6
2	Stefan-Maxwell approach for milticomponent mass transfer, Multicomponent distillation; Determination of key components at minimum reflux ratio by the method of Shiras, et al.Rigorous methods of Lewis-Matheson, Thiele-Geddes, bubble point, sum rates method, Naphthali-Sandholm method, residue maps.	10
3	Azeotropic and extractive distillation; stage wise calculations for multicomponent with multiplefeed streams	8
4	Liquid-liquid extraction; stage wise calculations for multicomponent with multiple feed streams using reflux and mixed solvents. Liquid-liquid extraction with chemical reaction	8
5	Multicomponent gas absorption: Horton-Franklin method, Edmister method. Mass transfer in gas absorption with and without chemical reaction, model solutions by Dankwerts; Brian; Perry and Pigford.	8

Suggested Books

S. No.	Name of Books/Authors/Publisher	Year of Publication/Reprint
1	Mass-transfer Operations/ R.E. Treybal/ McGraw-Hill	2017
2	Advanced Topics in Mass Transfer/ M. El-Amin/ BoD – Books on Demand	2011
3	Multicomponent Mass Transfer/ Ross Taylor, R. Krishna/ John Wiley & Sons.	2016
4.	Advanced Heat and Mass Transfer/ Amir Faghri, Yuwen Zhang, John R. Howell/ Global Digital Press.	2010

1. Subject Code: **CH413** Course Title: **Biochemical Engineering**
2. Contact Hours: L: 03 T: 01 P: 00
3. Examination Duration (Hrs.): Theory: 03 Practical: 00
4. Relative Weight: CWS: 25 PRS: 00 MTE: 25 ETE: 50 PRE: 00
5. Credits: 04
6. Semester: ODD-VII
7. Subject Area: DEC/GEC
8. Pre-requisite: NIL
9. Objective: To apply the chemical engineering principles in biological systems.
10. Course Outcomes: After completing this course, students would be able to

1. Understand the basic concepts of biochemical engineering.
2. Learn the process of enzyme kinetics with different substrates.
3. Learn the production of cell culture by mathematical modelling.
4. Explain the concept of bioreactors.
5. Understand the different transport phenomenon in bioprocess system.

11. Details of Course

S. No.	Contents	Contact Hours
1	Introduction to Biochemical Engineering: Comparative study of chemical and biochemical processes, Basic concepts of microbiology. Sterilization: Sterilization of air and medium; sterilization of fermentor, thermal death kinetics of microorganisms.	9
2	Biochemical Kinetics: Enzyme Kinetics with one or two substrates, modulation and regulation of enzyme activity, enzyme reactions in heterogeneous systems, Immobilized enzyme technology, Industrial application of enzymes.	9
3	Microbial Fermentation Kinetics**:** Fermentation and its classification, Growth-cycle phases (for batch cultivation), Continuous culture, Biomass production in cell culture, Mathematical modeling of batch growth,	8

	Product synthesis kinetics, Overall kinetics and thermal death kinetics of cells and spores, Analysis of multiple interacting microbial population.	
4	Bioreactors**:** Classification and characterization of different bioreactors e.g. batch and continuous, mechanically and non-mechanically agitated, CST type, tower, continuous, rotating, anaerobic etc., Design and analysis of Bioreactors - CSTR and Air Lift Reactor, Scale up considerations of bioprocesses.	9
5	Transport Phenomenon in Bioprocess Systems**:** Agitation and aeration-gas-liquid mass transfer, oxygen transfer rates, determination of kLa, Heat balance and heat transfer correlations. Commercial production of bioproducts: Concept of primary and secondary metabolites, Production processes for yeast biomass, antibiotics, alcoholic beverages and other products.	7

Suggested Books

S. No.	Name of Books/Authors/Publisher	Year of Publication /Reprint
1	Bioprocess Engineering: Basic Concepts/ Shuler M., Kargi F./ PHI	2012
2	Biochemical Engineering: A Textbook for Engineers, Chemists and Biologists/ S. Katoh, J. Horiuchi, F. Yoshida/ John Wiley & Sons.	2015
3	Biochemical Engineering Fundamentals/ Bailey J.E., Ollis D.F/ McGraw Hill, New York	2016
4.	Biochemical Engineering: An Introductory Textbook/ D. Das, D. Da/ CRC Press	2019

1. Subject Code: **CH415** Course Title: **Rocket Propulsion and Explosives**
2. Contact Hours: L: 03 T: 01 P: 00
3. Examination Duration (Hrs.): Theory: 03 Practical: 00
4. Relative Weight: CWS: 25 PRS: 00 MTE: 25 ETE: 50 PRE: 00
5. Credits: 04
6. Semester: ODD-VII
7. Subject Area: DEC/GEC
8. Pre-requisite: NIL
9. Objective: To impart knowledge about the propulsion, propellant, and explosives.
10. Course Outcomes: After completing this course, students would be able to

1. Explain the concepts of propulsion and rocket propulsion.
2. Explain the different types of propellants.
3. Understand the use of different energetic materials in explosives.
4. Learn the basic precautions and procedure during storage.
5. Understand the concept and use of plastic based explosive detector.

11. Details of Course

S. No.	Contents	Contact Hours
1	Concepts of propulsion, Fundamentals of Rocket Propulsion: Impulse, thrust, Energy efficiencies and Effective exhaust velocity, typical Performance values.	8
2	Propellants, Classification and Ingredients; Oxidizers and fuels; Selection criteria for oxidizers and fuels.	8
3	Explosives and High energy molecules, Energetic materials, Classification, precautions during storage.	9
4	Plastic based explosives, Advantages, Binders, Insults, Composition C-4; Semtex and related explosives	8
5	Plastic based explosive detectors, Fluorescing polymer; Portable Plastic Explosives Detector; Plastic Explosives for the Purpose of Detection; Anatomy of Explosives, Detection Equipment.	9

Suggested Books

S. No.	Name of Books/Authors/Publisher	Year of Publication/Reprint
1	Rocket Propulsion Elements, 8th Ed/ Sutton & Biblarz/ Wiley	2010
2	Propellants and Explosives: Thermochemical Aspects of Combustion/ Naminosuke Kubota/ f John Wiley & Sons.	2015
3	Rocket Propulsion/ K. Ramamurthi/ Macmillan Publishers.	2010
4	Science and Technology of Solid Rocket Propellants/ H. Singh, H. Shekhar/ Darbhanga	2005

1. Subject Code: **CH417** Course Title: **Polymer Waste Management**

2. Contact Hours: L: 03 T: 01 P: 00
3. Examination Duration (Hrs.): Theory: 03 Practical: 00
4. Relative Weight: CWS: 25 PRS: 00 MTE: 25 ETE: 50 PRE: 00
5. Credits: 04
6. Semester: ODD-VII
7. Subject Area: DEC/GEC
8. Pre-requisite: NIL
9. Objective: To impart knowledge about polymer waste and their management.

10. Course Outcomes: After completing this course, students would be able to

1. Identify the sources of plastic waste.

2. Describes the effects of plastic waste on environment, different toxic chemicals used in plastic industries and their effects on the environment.
3. Explain the plastic waste management methods including plastic recycling, effects of public awareness.
4. Provide the effective solutions for specific plastic waste case studies.
5. Describe various environmental policies, legislation & code of protection, imposed by different regulating bodies to limit effect of plastics on environment.

11. Details of Course

S. No.	Contents	Contact Hours
1	Polymer and Plastics Waste: Definition of plastics waste and the associated problems, Identification, collection methods and separation. Integrated waste management – source reduction, recycling, energy recovering process through thermal and biological destruction, Land filling and composting.	8
2	Plastics waste management: Source reduction, reuse, repair, recycling, and incineration with examples. Plastics recycling: Classification, Code of practice, Primary, secondary, territory and quaternary recycling with examples, Waste plastics as fillers.	8
3	Recycling and degradation of plastics: Recycling and sustainability correlation, Basic principles and recovery, recycling and resource conservation.	9
4	Recycling of plastics by surface refurbishing, Application of a coating, polishing, Plastics, Environmental and Thermal ageing, Chemical degradation, Wear and erosion, Biodegradable plastics – an overview.	9
5	Environmental issues, policies and legislation in India.	8

Suggested Books

S. No.	Name of Books/Authors/Publisher	Year of Publication/Reprint
1	Plastics Recycling – Products and Processes/ Ehrig (Ed.)/ Hanser Publication	1993
2	Recycling and recovery of plastics/ Brandrup/ Hanser Publishers, New York	1996
3	Handbook of Plastics Recycling/ By Francesco La Mantia/ Rapra Tech Ltd	2002
4	Introduction to Plastics Recycling/ By Vannessa Goodship/ Rapra Tech Ltd	2007

1. Subject Code: **CH419** Course Title: **Computational Fluid Dynamics**

2. Contact Hours: L: 03 T: 01 P: 00
3. Examination Duration (Hrs.): Theory: 03 Practical: 00
4. Relative Weight: CWS: 25 PRS: 00 MTE: 25 ETE: 50 PRE: 00
5. Credits: 04
6. Semester: ODD-VII
7. Subject Area: DEC/GEC
8. Pre-requisite: NIL
9. Objective: To make student aware about the concepts of computational fluid dynamics and its application in chemical engineering.

10. Course Outcomes: After completing this course, students would be able to

1. Identify different heat and mass transfer models.
2. Describe the concepts of computations fluid dynamics, its stability and consistency.
3. Use of Navier-Stoke Equation,and need for special methods for incompressible flows.
4. Apply classical and advanced iterative methods.
5. Generate structured and unstructured grid.

11. Details of Course

S. No.	Contents	Contact Hours
1	Conservation equations for mass, momentum, energy and chemical species; turbulence closure models; heat and mass transfer models; Wellposedness and boundary conditions.	08
2	Computations fluid dynamics concepts: discretisation, accuracy, consistency, stability and convergence; Lax's equivalence theorem; analysis for consistency; analysis for stability; template for the solution of a scalar transport equation	08
3	Solution of Navier-Stokes equations: methods for compressible flow; need for special methods for incompressible flows; artificial compressibility method; stream function-vorticity method; pressure equation method; the pressure correction approach	10
4	Solution of discretized equations: direct methods; classical iterative methods; advanced iterative methods	08
5	Grid generation: structure grid generation; unstructured grid generation	08

Suggested Books

S. No.	Name of Books/Authors/Publisher	Year of Publication /Reprint
1	Computational fluid mechanics and heat transfer/ R.H. Pletcher, J.C. Tannehill, D.A. Anderson/ CRC Press	2012
2	Numerical computation of internal and external flows: The fundamentals of computational fluid dynamics/ C. Hirsch/ Butterworth-Heinemann	2007

3	An introduction to computational fluid dynamics: The finite volume method/ H.K. Versteeg, W. Malalasekera/ Pearson Education	2007

1. Subject Code: **CH421** Course Title: **Polymer Reaction Engineering**
2. Contact Hours: L: 03 T: 01 P: 00
3. Examination Duration (Hrs.): Theory: 03 Practical: 00
4. Relative Weight: CWS: 25 PRS: 00 MTE: 25 ETE: 50 PRE: 00
5. Credits: 04
6. Semester: ODD-VII
7. Subject Area: DEC/GEC
8. Pre-requisite: NIL
9. Objective: To familiarize the students with kinetics of polymerization.
10. Course Outcomes: After completing this course, students would be able to

1. Explain the fundamental concepts of polymer reaction engineering.
2. Identify and describe the distinguished behaviours of polymerization reactors such as Changes in viscosity, density and rate constant with conversion and requirements of heat transfer.
3. Identify and classify different types of polymerization reactions based on their reaction mechanism.
4. Derive the kinetic models of different types of polymerization reactions.
5. Design the CSTR and PFR reactors for polymerization reactions.

11. Details of Course

S. No.	Contents	Contact Hours
1	Concepts of polymer reaction engineering, Fundamental concepts, Study of molecular weight distribution, Distinctive features of polymers and polymerization reactors, Changes in viscosity, density and rate constant with conversion.	10
2	Kinetics of polymerization, MW/MWD obtained for chain-growth, step-growth polymerization in batch reactor, Plug-flow reactor and continuous stirred tank reactor, kinetic studies of cationic, anionic and free radical polymerization reactions, Ziegler-Natta catalyst in stereo-regular polymerization, kinetics mechanism in heterogeneous and stereo-regular polymerization reactions, rates of Ziegler-Natta polymerization, average chain length of polymer in stereo-regular polymerization	10
3	Kinetics of emulsion and suspension polymerization, Introduction to bulk, solution, suspension and emulsion polymerization techniques, aqueous	11

	emulsifier solution, kinetic aspects of suspension and emulsion polymerization (Smith-Ewart Model), determination of total number of particles, molecular weight in emulsion polymerization, emulsion polymerization in homogenous CSTR, kinetics of dispersion polymerization.	
4	Kinetics at High Degree of Conversion, Verification of the kinetic model and the gel effect in radical polymerization, equilibrium of radical polymerization, temperature effects in radical polymerization, role of inter phase mass transfer in the selection and the design of polymerization reactor (especially step-growth polymerization reactors), diffusion effects in Ziegler-Natta polymerization and metallocene catalyst for olefin polymerization.	11

Suggested Books

S. No.	Name of Books/Authors/Publisher	Year of Publication/Reprint
1	Fundamentals of Polymer Engineering/ Kumar and Gupta/ Marcel Dekker.	2013
2	Modeling and Simulation in Polymer Reaction Engineering: A Modular Approach/ K. Hungenberg, M. Wulkow/ John Wiley & Sons	2018
3	Polymer Reactor Engineering/ C. McGreavy/ Springer	2013

1. Subject Code: **CH423** Course Title: **Optimization Techniques**
2. Contact Hours: L: 03 T: 01 P: 00
3. Examination Duration (Hrs.): Theory: 03 Practical: 00
4. Relative Weight: CWS: 25 PRS: 00 MTE: 25 ETE: 50 PRE: 00
5. Credits: 04
6. Semester: ODD-VII
7. Subject Area: DEC/GEC
8. Pre-requisite: NIL
9. Objective: To impart knowledge about optimization, related algorithms etc to the students.
10. Course Outcomes: After completing this course, students would be able to

1. Explain the applications of different types of optimization problems and their application in engineering field.
2. Develop a suitable mathematical model and corresponding objective function for given engineering optimization problem.
3. Solve single variable, multiple variable (unconstraint and constraint) optimization problems by using different optimization techniques.
4. Identify the most suitable optimization technique for a given problem.
5. Develop the algorithms on MATLAB/C++ for different optimization technics.
6. Solve linear programming problems numerically and develop the algorithm for them.

11 Details of Course:

S. No.	Contents	Contact Hours
1	Introduction: Engineering application of optimization, Design variables, constraints, objective function, variable bounds, statement and formulation of an optimization problem, Examples of chemical engineering, Optimization problems, classification of optimization problems, different optimization algorithms.	9
2	Optimal Point: Local optimal point, global optimal point and inflection point. Single variable, optimization techniques: Optimality criterion; Bracketing method (Bounding phase method); Region elimination methods (Internal halving method, Golden section search method); Point estimation method (successive quadratic estimation methods); Root finding using optimization techniques.	9
3	Multivariable Optimization Techniques: Optimality criterion; Unidirectional search method; Direct search method (Hooke-Jeeves Pattern Search method, Powell's conjugate direction method); Gradient-based methods (Steepest descent method, Newton's method, Marquardt's methods)	9
4	Constrained Optimization Algorithms: a. Kuhn - Tucker conditions b. Transformation method (penalty function method) c. Direct search for constrained minimization (variable elimination method, complex search method.)	8
5	Programming: Linear programing problems, Simplex method of linear Programming technique; Quadratic Programming.	7

Suggested Books

S. No.	Name of Books/Authors/Publisher	Year of Publication /Reprint
1	Optimization for Engineering Design: Algorithms and Examples/ Deb/ PHI	2012
2	Optimization of Chemical processes/ Edgar & Himmelblau/ McGraw Hill	2001
3	Process Optimization with Applications to Metallurgy & Chemical Engineering/ Ray & Szekely/ Wiley	1973
5.	Multi-objective Optimization: Techniques And Applications In Chemical/ G.P. Rangaiah/ World Scientific.	2016
6.	Engineering Optimization: Theory and Practice/ S.S. Rao/ John Wiley & Sons	2019

1. Subject Code: **CH425** Course Title: **Application of Polymers in Biomedical**
2. Contact Hours: L: 03 T: 01 P: 00
3. Examination Duration (Hrs.): Theory: 03 Practical: 00

4. Relative Weight: CWS: 25 PRS: 00 MTE: 25 ETE: 50 PRE: 00
5. Credits: 04
6. Semester: ODD-VII
7. Subject Area: DEC/GEC
8. Pre-requisite: NIL
9. Objective: To impart knowledge about bio-polymers, applications of polymers in biomedical fields
10. Course Outcomes: After completing this course, students would be able to

1. Analyze the properties of biopolymer
2. Describe the function of biomaterials
3. Tune the biopolymer properties for desirable biomedical applications
4. Identify application-oriented biopolymer products

11. Details of Course:

S. No.	Contents	Contact Hours
1	Natural polymers, synthetic polymers, biopolymers, biocompatibility of synthetic polymers. General Principles and properties of biomaterials, biofluids, cells, tissue and organs,	7
2	Properties of implant polymers. Biomedical applications of water soluble polymers, Hard tissue prosthesis, bone prosthesis, bone cement, soft tissue prosthesis, hydrogels, contact and intraocular lenses, wound dressing and sutures, organ repair, tissue engineering,	11
3	Polymer in drug delivery, gene therapy, synthetic gene delivery to cell, applications of polymers in specific biomedical uses/devises like syringe, catheters, hemodialysis, hemofiltration, artificial muscles/ soft actuators	8
4	Interface of polymers and biometrics, contraceptives based on polymers, Nano biomedical and molecular sensors.	8
5	Biosensors like glucose biosensor/ cholesterol/ urea and DNA biosensor, transducer, bioprocess monitoring and control, nano devices for early detection of different diseases.	8

Suggested Books

S. No.	Name of Books/Authors/Publisher	Year of Publication/Reprint
1	Advanced Functional Polymers for Biomedical Applications/ M. Mozafari, N.P.S. Chauhan/ Elsevier	2019
2	Biomedical Polymers/ Jenkin/ CRC Press	2007
3	Bioresorbable Polymers for Biomedical Applications/ G. Perale, J. Hilborn/ Woodhead Publishing	2016

4	Biomedical Applications of Polymeric Materials and Composites/ Raju Francis, D. Sakthi Kumar/ John Wiley & Sons. Copyright.	2016
5	Introduction to Biosensors: From Electric Circuits to Immunosensors/ Jeong-Yeol Yoon/ Springer.	2016

1. Subject Code: **CH427** Course Title: **Combustion Engineering**
2. Contact Hours: L: 03 T: 01 P: 00
3. Examination Duration (Hrs.): Theory: 03 Practical: 00
4. Relative Weight: CWS: 25 PRS: 00 MTE: 25 ETE: 50 PRE: 00
5. Credits: 04
6. Semester: ODD-VII
7. Subject Area: DEC/GEC
8. Pre-requisite: NIL
9. Objective: To familiarize students with combustion, fuels and their thermodynamic studies.
10. Course Outcomes: After completing this course, students would be able to

1. Explain and calculate different characteristics of combustion processes such as Moisture and heating value determination, flue gas analysis, flam properties etc.
2. Classify different types of fuels in terms of phases (solid, liquid, gases), and Characterize them in terms of their properties, application and environment footprint.
3. Apply the concepts of thermodynamics and chemistry to improve the efficiency of combustion processes and reduce the adverse effect on the environment.
4. Explain the combustion cycle of different types of solid liquid and gaseous fuels
5. Identify and Design different combustion techniques/burners used for solid, liquid and gaseous fuels.

11. Details of Course

S. No.	Contents	Contact Hours
1	Historical perspective of combustion science, perspective of fuels and combustion technology; Types and general characteristics of fuels, proximate and ultimate analysis of fuels. Moisture and heating value determination: gross and net heating values, claorimetry, DuLong's formula for HV estimation, Flue gas analysis, Orsat apparatus.	10
2	Classification of fuels; Solid fuels: Peat, coal, biomass, wood waste, refuse derived solid fuel, testing of solid fuels. Bulk and apparent density storage, washability, coking and caking coals.	8

	Liquid fuels: Liquid fuel types and their characteristics, Refining, molecular structure, fuel quality, Liquefaction of solid fuels. Gaseous fuels: Classification and characteristics.	
3	Thermodynamics and kinetics of combustion: Properties of mixture, combustion stoichiometry, chemical energy, properties of combustion products. First law combustion calculations: adiabatic flame temperature (analytical and graphical methods), Simple second law analysis. Elementary reactions: chain reactions, pre-ignition kinetics, reaction at solid surface.	8
4	Combustion of solid fuels; Drying, Devolatilization, Char combustion, Fixed bed combustion, Suspension burning, Fluidized bed combustion.	6
5	Combustion of liquid and gaseous fuels: Spray formation and droplet behaviour, Oil fired furnace combustion, Direct and indirect injection combustion in IC engines, Energy balance and furnace efficiency, gas burner types: pulse combustion furnace, Premixed charge engine combustion, Detonation of gaseous mixtures..	10

Suggested Books

S. No.	Name of Books/Authors/Publisher	Year of Publication /Reprint
1	Fundamentals of Combustion Engineering/ A. Mukhopadhyay, S. Sen/ CRC Press.	2019
2	Combustion science and Engineering/ Annamalai and Puri/ CRC Press	2007
3	Fuels and Combustion, 2nd Ed/ Sarkar/ Orient Longman	2003
4	Combustion Engineering and Gas Utilisation/ British Gas /Routledge.	2012

1. Subject Code: **CH429** Course Title: **Energy Resources**
2. Contact Hours: L: 03 T: 01 P: 00
3. Examination Duration (Hrs.): Theory: 03 Practical: 00
4. Relative Weight: CWS: 25 PRS: 00 MTE: 25 ETE: 50 PRE: 00
5. Credits: 04
6. Semester: ODD-VII
7. Subject Area: DEC/GEC
8. Pre-requisite: NIL
9. Objective: To study various types of conventional and non-conventional energy resources including solid, liquid and gaseous fuels.
10. Course Outcomes: After completing this course, students would be able to

1. Describe about Indian and World Energy Scenario and its resources
2. Understand the different types of energy, energy storage and energy conversion systems.
3. Learn the energy economy, conservation acts, final energy consumption energy needs of growing economy.

4. Understand of the energy and environment, air pollution climate changes and its impacts on sustainable development

11. Details of Course

S. No.	Contents	Contact Hours
1	Energy Scenario: Indian and global, Present and future energy demands, Energy crisis, Classification of various energy sources, Renewable and non-renewable energy sources, Pattern of energy consumption	6
2	Solid Fuels: Coal: Origin, formation, analysis, classification, washing and carbonization, Treatment of coal gas, Recovery of chemicals from coal tar, Coal gasification, Liquid fuel synthesis from coal, Carbonization of coal, Briquetting of fines.	8
3	Liquid and Gaseous Fuels: Crude petroleum, Physical processing of crude petroleum, Fuels from petroleum, Storage and handling of liquid fuels, Natural and liquefied petroleum gases, Gas hydrates, Gasification of liquid fuels, Carbureted water gas.	10
4	Fuel Characterization: Viscosity, Viscosity index, Flash point, Cloud point, Pour point, Fire point, Smoke point and Char value, Carbon residue, Octane number, Cetane number, Aniline point and Performance number, Acid value, ASTM distillation, Calorific value, Proximate and ultimate analysis.	10
5	Alternate Energy Sources: Solar energy: Radiation measurement, applications and types of collectors and storage, Wind power, Geothermal energy, Tidal energy, Nuclear power, Fuel cells, Biogas, Biomass..	8

Suggested Books

S. No.	Name of Books/Authors/Publisher	Year of Publication /Reprint
1	Fuels and Fuel Technology/ W. Francis/ Elsevier	2016
2	Energy Resources Around the World/ S. Beres/ Benchmark Education Company	2011
3	Fuel Solid, Liquid and Gases/ J.S.S. Brame and J.G. King/ Edward Arnold	2004
4	Fundamentals and Practices in Colouration of Textiles, Second Edition/ J N Chakraborty/ Woodhead Publishing.	2014

1. Subject Code: **CH431** Course Title: **Membrane Technology**
2. Contact Hours: L: 03 T: 01 P: 00
3. Examination Duration (Hrs.): Theory: 03 Practical: 00
4. Relative Weight: CWS: 25 PRS: 00 MTE: 25 ETE: 50 PRE: 00
5. Credits: 04

6. Semester: ODD-VII
7. Subject Area: DEC/GEC
8. Pre-requisite: NIL
9. Objective: To make student aware about the theory, principle and applications of membrane.

10. Course Outcomes: After completing this course, students would be able to

1. Explain the basic concept of membrane technology and describe various membrane based processes based on their characteristics and applications.
2. Synthesize the polymeric and inorganic membrane by phase inversion and gel formation methods respectively.
3. Classify the different membrane based technics based on the types of membrane used, driving force, fluxes and final applications.
4. Develop mathematical equations to model membrane based processes by using various laws of mass transfer, thermodynamics and fluid mechanics.
5. Design simple membrane modules for achieving desired separation in a given application.
6. Troubleshoot the problems related to membrane technology such as concentration polarization, membrane fouling, gel-layer creation etc.

11.. Details of Course

S. No.	Contents	Contact Hours
1	Introduction of different types of membrane based processes, classification of membrane processes based on driving force, pore size, application and types of membranes used. Membrane synthesis or organic and inorganic membranes.	8
2	Reverse osmosis process, concept of concentration polarization, film theory for concentration polarization, solution diffusion model and Non-equilibrium thermodynamics based models, Membrane used and applications. Membrane modules and its classifications.	8
3	Liquid-Liquid membranes, classification, applications, different transport mechanism in liquid membrane transport, Electro-dialysis process, membranes, classification, applications, limiting current, transport number, bipolar membranes and its applications.	8
4	Ultrafiltration and nanofiltration process, application, classification, pore size of membrane, mathematical modelling based on solution diffusion and pore flow model, membrane fouling, limiting flux, characteristics of membranes.	8

5	Gas separation and pervaporation process, application, membrane characteristics, mathematical modelling New membrane based process and other applications: Forward Osmosis, Pressure Retarded Osmosis, Membrane Contractor, Membrane Reactors	10

Suggested Books

S. No.	Name of Books/Authors/Publisher	Year of Publication /Reprint
1	Basic Principles of Membrane Technology/ M. Mulder/ Springer	2012
2	Chemical Process: Design and Integration/ Smith/ Wiley	2005
3	Synthetic Polymer Membranes/ Khulbe et al/ Springer	2008
4	Membrance Technology & Applications, Baker, Wiley Blackwell	2012

Departmental Elective Courses

8th Semester

Elective VII and Elective VIII

1. Subject Code: **CH404** Course Title: **Fuel Cell Technology**
2. Contact Hours: L: 03 T: 01 P: 00
3. Examination Duration (Hrs.): Theory: 03 Practical: 00
4. Relative Weight: CWS: 25 PRS: 00 MTE: 25 ETE: 50 PRE: 00
5. Credits: 04
6. Semester: EVEN-VIII
7. Subject Area: DEC/GEC
8. Pre-requisite: NIL
9. Objective: To impart knowledge about the properties, applications and components of fuel cells.

Course Outcomes: After completing this course, students would be able to

1. Explain the technical aspects of fuel cells, working, types, basic components etc.
2. Explain the thermodynamics and electrochemical kinetics of reactions involving in fuel cells.
3. Identify the technical requirements of various components of fuels cells.
4. Identify or developed different materials used in various components of fuel cell.
5. Perform the testing of fuel cell components to characterize them for their performance in the fuel cell.
6. Identify the different applications of fuel cell and design fuel cell for these applications.

11. Details of Course

S. No.	Contents	Contact Hours
1	Fuel cells, Working and types of fuel cell, Low, medium and high temperature fuel cell, Liquid and methanol types, Proton exchange membrane fuel cell, Solid oxide, Hydrogen fuel cells, Thermodynamics and electrochemical kinetics of fuel cells, Fuel cell reaction kinetics, Electrode kinetics.	9
2	Fuel cells for automotive applications, Technology advances in fuel cell vehicle systems, Onboard hydrogen storage, Liquid hydrogen and compressed hydrogen, Metal hydrides, Fuel cell control system, Alkaline fuel cell.	9
3	Electrode assembly components, Fuel cell stack, Bi-polar plate, Humidifiers and cooling plates, Fuel cell performance characteristics, Current/voltage, Voltage efficiency and Power density, Ohmic resistance, Kinetic performance, Mass transfer effects.	8
4	Hydrogen, Its merit as a fuel, Applications, Hydrogen production methods, Production from fossil fuels, Electrolysis, Thermal	9

	decomposition, Photochemical and Photo-catalytic methods, Hydrogen storage methods, Metal hydrides, metallic alloy hydrides, carbon nano-tubes, sea as source of deuterium, Hydrogen storage technology, pressure cylinders, liquid hydrogen, metal hydrides, carbon fibers, reformer technology, steam reforming, partial oxidation, auto thermal reforming, CO removal.	
5	Fuel cycle analysis, Application to fuel cell and other competing technologies like battery powered vehicles, si-engine fueled by natural gas and hydrogen and hybrid electric vehicle.	7

Suggested Books

S. No.	Name of Books/Authors/Publisher	Year of Publication /Reprint
1	Fuel Cells: From Fundamentals to Applications/ S. Srinivasan/ Springer.	2006
2	Hydrogen and Fuel Cells: Emerging Technologies and Applications/ B. Sørensen, G. Spazzafumo/ Academic Press	2018
3	Fuel Cells: Current Technology Challenges and Future Research Needs/ N.H. Behling/ Elsevier	2014
4	Direct Methanol Fuel Cell Technology/ K. Dutta/ Elsevier	2020

1. Subject Code: **CH406** Course Title: **Catalysis**
2. Contact Hours: L: 03 T: 01 P: 00
3. Examination Duration (Hrs.): Theory: 03 Practical: 00
4. Relative Weight: CWS: 25 PRS: 00 MTE: 25 ETE: 50 PRE: 00
5. Credits: 04
6. Semester: EVEN-VIII
7. Subject Area: DEC/GEC
8. Pre-requisite: NIL
9. Objective: To impart knowledge about Catalysis Technology and Its application in Chemical Industries
10. Course Outcomes: After completing this course, students would be able to

1. Identify homogeneous and heterogeneous catalysis.
2. Understand theory of the acid-base catalysis the reaction intermediates.
3. Understand the reactions of transition metal complexes in endustrial reactions.
4. Understand heterogeneous catalysis and its areas of applications.
5. Identify irreversible catalytic unimolecular and bi-molecular reactions.

11. Details of Course:

S. No.	**Contents**	**Contact Hours**
1	Introduction to catalysis: Fundamental Concepts of Homogeneous catalysis, Fundamental Concepts of Heterogeneous catalysis,	8

	advantages and disadvantages, Theoretical bases: Theories of acid-base, Acid-base equilibrium and acidity function.	
2	Kinetics of proton transfer reactions: Theory quantum chemistry proton transfer, Theory of the acid-base catalysis the reaction intermediates, Reactions catalyzed by acids and bases, Esterification and hydrolysis of esters, Hydrolysis of amides and acids, Acid catalysis and its industrial applications, Main industrial catalysts, Catalytic cracking, Isomerization of light alkanes.	10
3	Transition elements: Introduction, Definitions, Coordination complexes, Stereochemistry of the transition metal complex, Reactions of transition metal complexes, Notion of catalytic cycle and different types of initiation complex, Tolman rule (16-18 electrons), fundamental reactions of complex, Industrial examples Hydrogenation, asymmetric catalysis, hydrocyanation, Hydroformylation, carbonylation, relationship, Oligomerization and polymerization of olefins , Oxidation reactions.	8
4	Concepts of heterogeneous catalysis: Introduction and Definition History , catalysts and catalytic properties, general mechanism of action catalyst, Heterogeneous catalysis Area of application: reactions and catalytic processes , catalytic converter, general mechanisms: diffusion, adsorption - desorption kinetics	8
5	Catalytic Cycle: Irreversible unimolecular reaction. Irreversible bimolecular reaction, Mechanism of Langmuir- Hinshelwood: competitive adsorption and non-competitive. Adsorption mechanism Eley - Rideal	8

Suggested Books

S. No.	Name of Books/Authors/Publisher	Year of Publication/Reprint
1	Catalysis: An Integrated Textbook for Students/ U. Hanefeld, L. Lefferts/ John Wiley & Sons	2018
2	Homogeneous Catalysts: Activity, Stability, Deactivation/ John C. Chadwick, Rob Duchateau, Zoraida Freixa, Piet W. N. M. van Leeuwen/ Wiley	2011
3	Heterogeneous Catalysis: Fundamentals and Applications/ J. R. H. Ross/ Elsevier	2012

1. Subject Code: **CH408** Course Title: **Speciality Polymers**
2. Contact Hours: L: 03 T: 01 P: 00
3. Examination Duration (Hrs.): Theory: 03 Practical: 00
4. Relative Weight: CWS: 25 PRS: 00 MTE: 25 ETE: 50 PRE: 00
5. Credits: 04
6. Semester: EVEN-VIII
7. Subject Area: DEC/GEC

8. Pre-requisite: NIL

9. Objective: To impart knowledge to student about special polymers and their applications.

Course Outcomes: After completing this course, students would be able to

1. Explain the basic concepts of polymer Speciality polymers, classify them based of chemical group presents, physical and chemical properties, specific properties such as PEEK, PI, PS, Liquid Crystals, Conducting and non-conducting polymers etc.
2. Describe the speciality polymer synthesis and their special properties.
3. Correlate the chemical structure of speciality polymers to their special properties.
4. Apply knowledge of structure property correlations to synthesis of speciality polymers of desired properties.
5. Identify different speciality polymers for specific applications such as electronics and telecommunications, bio-technology and biomedical field etc.
6. Characterize the specific properties through various testing methods for their special properties.

11. Details of Course

S. No.	Contents	Contact Hours
1	Concepts of speciality polymers, High temperature and fire resistant polymers, Applications of heat resistant polymers like polyamides, polyimides, polyquinolines, polyquinoxalines, PEEK, silicone, polysiloxane, polyphosphazenes, ladder polymer, barrier polymer, dendritic polymers, telechelic polymer, luminescent polymer.	10
2	Conducting polymers, types of conducting polymers, doping of polymeric systems, conduction mechanism, Synthesis, curing reactions, and technological applications of Polyaniline, Polyacetylene, Polypyrrole, Photo-conducting and piezoelective polymers.	10
3	Polymers in corrosion inhibition, Polymers as antistatic agents, Polymer colloids, Polymeric surfactants, Polymers in conversion and storage of solar energy.	7
4	Polymers in telecommunications and power transmission - liquid crystalline polymers, Polymer impregnated concrete ultra-high modulus fibres.	5
5	Synthesis, physical properties and applications of biomedical polymers, hydrophilic polymers and ionic polymers, Natural and synthetic biopolymers and their biomedical applications.	6
6	Recent advancements in speciality polymers.	4

Suggested Books

S. No.	Name of Books/Authors/Publisher	Year of Publication /Reprint
1	Handbook of Specialty Fluorinated Polymers: Preparation, Properties, and Application/ S. Banerjee/ Plastic Design Library	2015
2	Functional Polymers/ Bergbreiter & Martin/ Springer	2010
3	Contemporary Topics in Polymer Science/ W.J. Bailey/ Springer	2014
4	Handbook of Conducting Polymers/ Skotheim & Reynolds/ CRC Press	2007
5.	Conducting Polymers/ Faris Yılmaz/ BoD – Books on Demand	2016

1. Subject Code: **CH410** Course Title: **Process Engineering and Design**
2. Contact Hours: L: 03 T: 01 P: 00
3. Examination Duration (Hrs.): Theory: 03 Practical: 00
4. Relative Weight: CWS: 25 PRS: 00 MTE: 25 ETE: 50 PRE: 00
5. Credits: 04
6. Semester: EVEN-VIII
7. Subject Area: DEC/GEC
8. Pre-requisite: NIL
9. Objective: To impart knowledge about process equipment design to the students.

10. Course Outcomes: After completing this course, students would be able to

1. Design evaporators, Dryers and Furnaces.

2. Design Heat Exchangers.

3. Identify general design considerations of cyclone separators, centrifuges, clarifiers, crystallizers and other separation equipment.

4. design various mass transfer equipments.

5. Design different types of reactors for homogeneous and heterogeneous reactions.

11. Details of Course:

S. No.	**Contents**	**Contact Hours**
1	Design of evaporator: Introduction, types of evaporators, methods of feeding of evaporators, general design consideration of evaporator. Design of driers: Introduction, types driers, design consideration of driers Design considerations of different types of furnaces	8
2	Process Design of Heat Exchanger: Types of Heat exchanger, process design of shell and tube heat exchanger, condenser, and reboilers.	8

3	Separation Equipments: General design considerations of cyclone separators, centrifuges, clarifiers, crystallizers, flash drums, separation equipments etc.	8
4	Design considerations of mass transfer units: Design considerations of distillation, absorption, adsorption, striping, liquid-liquid separation columns, NTU, HTU calculations, Energy requirement calculations, design considerations of packaging materials and trays.	8
5	Design considerations of reactors, homogeneous reactors (batch reactors, mixed flow reactors, plug flow reactors), Heterogeneous reactors (Fixed bed rectors, fluidized bed reactors, slurry reactors, bubble column rectors)	8

Suggested Books

S. No.	Name of Books/Authors/Publisher	Year of Publication/Reprint
1	Chemical Engineers' Handbook/ R.H.Perry/ McGraw-Hill	2007
2	Introduction to Process Engineering and Design/ S.B. Thakore, B.I. Bhatt/ McGraw-Hill	2015
3	Chemical Engineering Volume 6 - Chemical Engineering Design/ J.M. Coulson and J. Richardson/ Asian Books Printers Ltd.	2005

1. Subject Code: **CH412** Course Title: **Thermoplastic Elastomers**
2. Contact Hours: L: 03 T: 01 P: 00
3. Examination Duration (Hrs.): Theory: 03 Practical: 00
4. Relative Weight: CWS: 25 PRS: 00 MTE: 25 ETE: 50 PRE: 00
5. Credits: 04
6. Semester: EVEN-VIII
7. Subject Area: DEC/GEC
8. Pre-requisite: NIL
9. Objective: To familiarize the students with thermoplastic elastomers, types and their properties.
10. Course Outcomes: After completing this course, students would be able to

Course Outcomes: After completing this course, students would be able to

1. Describe the basic concepts of thermoplastic elastomers, its properties and applications.
2. Explain the Synthesis, properties, and applications of various thermoplastic elastomers.
3. Apply structure-property correlations of thermoplastic elastomers to synthesis new elastomers of desired properties.
4. Develop new blends of thermoplastic elastomers to achieve desired properties.

5. Perform various testing to characterize thermoplastic elastomers (mechanical, thermal, chemical and morphological testing)

11. Details of Course

S. No.	Contents	Contact Hours
1	Thermoplastic Elastomers (TPEs), Elastomers, Thermodynamics of elasticity, Thermoplastic elastomers, Classification, structure and synthesis of TPEs.	8
2	Polyolefin based thermoplastic elastomers, Synthesis, Properties, Processing and Applications, PVC based TPE-PVC/Nitrile rubber blends, PVC/PU blends, PVC/Co-polyester elastomers blends, Styrenic TPEs.	9
3	Thermoplastic polyurethane elastomers, Synthesis, Properties, Processing and Applications, Polyamide based TPE, Structure-property relationship, Thermoplastic polyether ester elastomers.	9
4	Preparation of dynamically vulcanized thermoplastic elastomer blends, Properties and applications, Synthesis of ionomeric TPE, Ionic interactions in polymer blends, Applications of ionomeric elastomers.	8
5	Secondary manufacturing processes technology of TPEs, process simulation, 3D printing, product development and testing; Recycling methods for thermoplastic elastomers. Recent developments and trends in the field of thermoplastic elastomers.	8

Suggested Books

S. No.	Name of Books/Authors/Publisher	Year of Publication /Reprint
1	Thermoplastic Elastomers: Synthesis and Applications/ C.K. Das/ BoD – Books on Demand.	2015
2	Handbook of Thermoplastic Elastomers/ Drobny/ William Andrew Publishing, New York, USA, 2nd Edition.	2007
3	Applied Plastic Engineering Handbook: Processing and Materials, Chapter on Thermoplastic Elastomers/ Holden, G/ Elsevier, Oxford, UK.	2011

1. Subject Code: **CH414** Course Title: **Nonwoven Technology**
2. Contact Hours: L: 03 T: 01 P: 00
3. Examination Duration (Hrs.): Theory: 03 Practical: 00
4. Relative Weight: CWS: 25 PRS: 00 MTE: 25 ETE: 50 PRE: 00
5. Credits: 04
6. Semester: EVEN-VIII
7. Subject Area: DEC/GEC
8. Pre-requisite: NIL

9. Objective: To enable the students to learn about Non-wovens, bonding processes, finishing process etc.

10. Course Outcomes: After completing this course, students would be able to

1. Explain different expects of Non-woven manufacturing, basic properties of fibres and geometry of fibres.
2. Perform the Staple-fibre based non-woven manufacturing processes, Identify and optimize the process parameters of these processes.
3. Perform the Web and Mechanical bonding, chemical bounding, thermal bounding and ultrasonic bounding non-woven manufacturing processes, Identify and optimize the process parameters of these processes.
4. Perform the Polymer-extrusion based technologies non-woven manufacturing processes, Identify and optimize the process parameters of these processes.
5. Apply the different chemical, thermal and mechanical finishing processes.

11. Details of Course

S. No.	Contents	Contact Hours
1	Concepts of nonwovens, Elements of nonwovens, Fibre geometry, Structure of fibrous webs, Basic nonwoven processes and their sequences.	8
2	Staple-fibre based processes, Fibre opening and mixing processes, Staple fibre web formation processes, Carding process, Parallel-lay process, Cross-lay process, Perpendicular-lay process, Air-lay process, Wet-lay process.	8
3	Web and Mechanical bonding processes, Needle-punch and Hydro entanglement process, Principle and processes of thermal bonding, Calendar, Through-air, Infra-red, Ultrasonic and Chemical bonding processes, Chemical binders, Methods of binder applications, Saturation, Foam, Spray and Print bonding process, Methods of drying.	10
4	Polymer-extrusion based technologies, Spun bond technology, Melt-blown technology, Key process factors.	8
5	Mechanical and chemical finishes and their method of applications.	8

Suggested Books

S. No.	Name of Books/Authors/Publisher	Year of Publication /Reprint
1	Nonwoven/ Madhavamoorthy and Shetty/ Mahajan Publishers Pvt. Ltd.	2005
2	Handbook of Nonwovens/ S.J. Russell (Ed.)/ Woodhead Publishing, CRC Press, Washington DC.	2007

3	Nonwoven Fabrics: Raw Materials, Manufacture, Applications, Characteristics, Testing Process/ Albrecht, Fuchs and Kettelmann/ Wiley-VCH.	2003
4.	Nonwovens: Process, Structure, Properties and Applications/ T. Karthik, Prabha Karan C., R. Rathinamoorthy/ CRC Press.	2017
5.	Composite Nonwoven Materials: Structure, Properties and Applications/ Dipayan Das, Behnam Pourdeyhimi/ Elsevier.	2014

1. Subject Code: **CH416** Course Title: **Industrial Waste Management**
2. Contact Hours: L: 03 T: 01 P: 00
3. Examination Duration (Hrs.): Theory: 03 Practical: 00
4. Relative Weight: CWS: 25 PRS: 00 MTE: 25 ETE: 50 PRE: 00
5. Credits: 04
6. Semester: EVEN-VIII
7. Subject Area: DEC/GEC
8. Pre-requisite: NIL
9. Objective: To make student understand about the impact on environment due to the effluents of industries.

Course Outcomes: After completing this course, students would be able to

1. Describe and classify different types of industrial waste produced by various industries.
2. Explain various adverse effects of different industrial waste on the environment and human health.
3. Perform various testing to characterize the pollutants present in the industrial waste.
4. Explain various industrial waste treatment methods to treat, solid, liquid and gaseous industrial waste.
5. Identify and design the waste treatment units for specific type of industrial waste.
6. Describe different regulations, standers imposed by various regulating bodies to limit the adverse effects of industrial waste.

11. Details of Course

S. No.	Contents	Contact Hours
1	Magnitude of industrial waste generation and their characteristics, Effluent standards for disposal into water bodies, sewer & land, Waste water characterization and process survey, Methods of waste reduction such as volume & strength reduction, segregation, reuse, recycle, material conservation, recovery process optimization, neutralization, equalization, proportioning and solidification.	11

2	Theories of waste water treatment, Pre-treatment, Biological treatment, Advanced treatment & sludge handling.	7
3	Combined treatment of raw industrial waste with sewage, Common effluent treatment for industrial estates, Selection procedure for physical, chemical & biological methods of industrial waste treatment, Management of industrial waste from small-scale industries.	9
4	Gross polluting industries, Detailed considerations of waste produced from different industries, Nature & quantity of wastes, their characteristics, usual methods of waste management & treatment methods.	9
5	e-Wastes, Problem and solutions, Regulatory authorities, regulations and compliance.	6

Suggested Books

S. No.	Name of Books/Authors/Publisher	Year of Publication /Reprint
1	Handbook of Industrial Waste Treatment/ Woodard/ Elsevier	2011
2	Waste water microbiology 4th Ed/ Bitton/ Wiley	2011
3	Industrial Waste: Management, Assessment and Environmental Issues/ S.N. Barton/ Nova Science Publishers	2016
4	Sustainable Industrial Design and Waste Management: Cradle-to-Cradle/ Salah El Haggar/ Academic Press	2007
5.	Industrial Waste Management/ Zander Ellis/ Larsen and Keller Education	2017

1. Subject Code: **CH418** Course Title: **Application of Nanotechnology in Polymers**
2. Contact Hours: L: 03 T: 01 P: 00
3. Examination Duration (Hrs.): Theory: 03 Practical: 00
4. Relative Weight: CWS: 25 PRS: 00 MTE: 25 ETE: 50 PRE: 00
5. Credits: 04
6. Semester: EVEN-VIII
7. Subject Area: DEC/GEC
8. Pre-requisite: NIL
9. Objective: To make student aware about the applications of nanomaterials in various fields.

10. Course Outcomes: After completing this course, students would be able to

1. Describe the different aspects of nanotechnology, Identify and classify the material properties at nano-scale, and its applications in different sectors.

2. Synthesize different nanomaterials by using various physical and chemical roots.

3. Characterize the nanomaterials based on their special properties by using various testing methods.

4. Identify and apply the nanomaterial in the field of Electronics and biotechnology.

5. Describe the advancements in the field of nanotechnology

11. Details of Course

S. No.	Contents	Contact Hours
1	Introduction to nanomaterials and nanocomposites, types of nanomaterials and their morphology.	5
2	Preparation, structure, properties and of nano-reinforcing agents such as nanoclays, POSS, carbon nanostructures, metals, and metal oxides nanoparticles.	10
3	Effect of factors such as loading, dispersion and distribution, influence of size, shape and diameter of nanomaterials, functionalization of nanomaterials.	10
4	Structural and morphological characterization of nanocomposites and nanomaterials.	9
5	Applications of polymeric nanocomposites, recent development of nanomaterials and nanocomposites	8

Suggested Books

S. No.	Name of Books/Authors/Publisher	Year of Publicatio/Reprint
1	Polymer Nanocomposites: Synthesis, Applications and Research/ H. Thompson/ Nova Science Publishers	2017
2	Nanoscience: Nanotechnologies and Nanophysics/ Dupas, Houdy, Lahmani/ Springer-Verlag Berlin Heidelberg	2007
3	Nanostructured Materials and Nanotechnology/ H.S. Nalwa/ Academic Press	2002
4	A Textbook of Nanoscience and Nanotechnology/ Pradeep/ Tata McGraw Hill Education Pvt. Ltd.	2012
5	Advances in Polymer Nanocomposites: Types and Applications/ F. Gao/ Elsevier	2012

1. Subject Code: **CH420** Course Title: **Inorganic Polymers**
2. Contact Hours: L: 03 T: 01 P: 00
3. Examination Duration (Hrs.): Theory: 03 Practical: 00
4. Relative Weight: CWS: 25 PRS: 00 MTE: 25 ETE: 50 PRE: 00
5. Credits: 04
6. Semester: EVEN-VIII
7. Subject Area: DEC/GEC

8. Pre-requisite: NIL

9. Objective: To familiarize the students about synthesis, physical and chemical properties and applications of inorganic polymers.

10. Course Outcomes: After completing this course, students would be able to

1. Identify Inorganic polymer, list their properties and classify inorganic polymers and recognize the difference between organic polymers and inorganic polymers
2. Analyse type of substance is prone to inorganic polymerization
3. Recognize Phosphorus, Phosphorus-nitrogen compounds and polymers, interpret synthetic methods and their application areas.
4. Describe the synthesis methods of many inorganic polymers and interpret their features
5. Recognize synthetic inorganic fibers and relate applications of Inorganic Polymers in Technology

11. Details of Course

S. No.	Contents	Contact Hours
1	Introduction, Types of inorganic polymers and their special characteristics.	5
2	Characterization of inorganic polymers, Molecular weights, Molecular weight distributions, Chain statistics, Solubility considerations, Crystallinity, Transitions, Spectroscopy, Mechanical properties.	9
3	Polyphosphazenes: Synthesis, Ring opening polymerization, Mechanism, Structure-property relationships; Advanced elastomeric, Fibres, and Film forming, Polyphosphazenes, Polyphosphazenes as biomedical materials, Organometallic polyphosphazenes, Liquid crystalline and high refractive index polymers, Polycarbophosphazenes and polythiophosphazenes.	11
4	Polysilanes and related polymers: Introduction, Synthesis and Chemical modification of polysilanes, Physical properties of polysilanes, Electronic properties and conformations, Photo-degradation of polysilanes, Structure of polysilanes, Technology of polysilanes.	10
5	Miscellaneous inorganic polymers: Boranes, Polymers containing sulfur and nitrogen – properties and applications.	7

Suggested Books

S. No.	Name of Books/Authors/Publisher	Year of Publication /Reprint
1	Inorganic Polymers, Second Edition/ Mark, Allcock and West/ Oxford	2005
2	Smart Inorganic Polymers: Synthesis, Properties, and Emerging Applications/ E. Hey-Hawkins, M. Hissler/ John Wiley & Sons	2019
3	Inorganic Polymers/ G. R. Chatwal/ Himalaya Publishing House	2013

4	Inorganic Polymers/ Saxena/ Discovery Publishing House	2007

1. Subject Code: **CH422** Course Title: **Pharmaceutical Technology**
2. Contact Hours: L: 03 T: 01 P: 00
3. Examination Duration (Hrs.): Theory: 03 Practical: 00
4. Relative Weight: CWS: 25 PRS: 00 MTE: 25 ETE: 50 PRE: 00
5. Credits: 04
6. Semester: EVEN-VIII
7. Subject Area: DEC/GEC
8. Pre-requisite: NIL
9. Objective: To impart knowledge about the design, development, applications and packaging of pharmaceutical compounds.
10. Course Outcomes: After completing this course, students would be able to

1. Explain the technical aspects of pharmaceutical technology such as types of drug delivery systems, basics of drug design, targeted drug delivery systems, clinical trials etc.
2. Identify or develop new drugs and characterize them by using various testing methods.
3. Develop new drug delivery systems and characterize them by using various testing methods.
4. Design the packaging of drugs based on their specific storage, transportation and packaging requirements.
5. Describe the different regulations related to drugs imposed by various regulating bodies.

11. Details of Course

S. No.	Contents	Contact Hours
1	Drug discovery process and drug design: Introduction to drug discovery, Various stages in the process of drug design and molecular discovery to commercialization, Target selection, Drug receptor interaction, Drug action theories, Synthetic methods, Screening approaches, PK & PD, ADMET, Various phases of clinical trials.	10
2	Process technology for drugs and intermediates: Manufacturing processes for drugs and their comparative study, Optimization of organic reactions and processes and scale up, Development techniques for safe process design, Unit operations posing particular hazards during development, Chemical hazards assessment, Process control consideration and safety critical systems, GMP in chemical development.	10

3	Drug delivery systems: Conventional and recent pharmaceutical dosage forms and drug delivery systems, Polymers in Drug delivery modules, Radio pharmaceuticals.	8
4	Pharmaceutical packaging technology: Introduction to Packaging, Classification of packaging, Essential requirements, Functions of packaging, significance of pharma packaging, Properties of ideal package, Packaging formats and materials in pharma industry, New trends in the pharmaceutical packaging.	8
5	Validation and Regulatory requirements: CGMP and Quality assurance, Process, product validation and quality audits, New drug application, generic products, DPCO/NPPA, drugs and cosmetics act and rules including licensing intermediates industry.	6

Suggested Books

S. No.	Name of Books/Authors/Publisher	Year of Publication /Reprint
1	Foye's Principles of Medicinal Chemistry/D.A. Williams, 7th Edition.	2012
2	Wilson and Gisvold's Textbook of Organic Medicinal and Pharmaceutical Chemistry/ John M. Beale, Jr., John H. Block, Twelfth edition	2011
3	Ansel's Pharmaceutical Dosage Forms and Drug Delivery Systems, Howard C. Ansel, 9th Edition,	2011

1. Subject Code: **CH424** Course Title: **Safety & Hazards in Chemical Industries**
2. Contact Hours: L: 03 T: 01 P: 00
3. Examination Duration (Hrs.): Theory: 03 Practical: 00
4. Relative Weight: CWS: 25 PRS: 00 MTE: 25 ETE: 50 PRE: 00
5. Credits: 04
6. Semester: EVEN-VIII
7. Subject Area: DEC/GEC
8. Pre-requisite: NIL
9. Objective: To make student aware about the safety aspects in chemical industries.

10. Course Outcomes: After completing this course, students would be able to

1. Explain basic concepts of plant safety, requirements of plant safety, various plant safety regulations etc.
2. Identify and analyse origins of various types of hazards.
3. Provide the solutions and preventions for various types of hazards.
4. Describe the hazards related to chemical storage, transportation and handling, their causes, effects and preventions.
5. Describe various risk analysis technics, risk management systems.
6. Perform Safety audits based on various risk analysis technics.
7. Explain the Safety Regulations for chemical plants imposed by different regulating bodies.
8. Design and organize safety training for employees of a particular industry.

11. Details of Course

S. No.	Contents	Contact Hours
1	Plant safety and safety regulations, Safety in chemical & polymer industries, Origin of process hazards, Laws, Codes, Standards, Case histories, Criteria for setting & layout of chemical plant, Factories Act and Safety Regulations.	9
2	Plant hazards such as Fire, Chemicals, Explosion, Electrical, Mechanical, Radiation and Noise, Control, precautions & prevention, Safety measures in plants.	8
3	Storage and transportation of chemicals, Characteristics of chemicals with special reference to safe storage & handling, Layout of storage, Various modes of transport and safety precautions in transportation of different types of chemicals.	5
4	Risk management principles, Risk analysis techniques, Hazard & operability studies, Hazard analysis, Fault tree analysis, Consequence analysis, Human error analysis, Accident error analysis, Economics of risk management.	10
5	Safety Audit, Procedure for safety auditing, Audit report, Safety report.	6
6	Safety training, Emergency planning and disaster management.	4

Suggested Books

S. No.	Name of Books/Authors/Publisher	Year of Publication /Reprint
1	Safety and Hazards Management in Chemical Industries/ Vyas/ Atlantic.	2013
2	Chemical Hazards and Safety, 2nd Ed/ Dawande/ Denett & Co.	2012
3	Loss Prevention in the Process Industries/ Lees/ Butterworth-Heinemann	2014
4	Industrial Safety Handbook/ William & Handley/ McGraw Hill.	-

1. Subject Code: **CH426** Course Title: **Biofuel Engineering**
2. Contact Hours: L: 03 T: 01 P: 00
3. Examination Duration (Hrs.): Theory: 03 Practical: 00
4. Relative Weight: CWS: 25 PRS: 00 MTE: 25 ETE: 50 PRE: 00
5. Credits: 04
6. Semester: EVEN-VIII
7. Subject Area: DEC/GEC
8. Pre-requisite: NIL
9. Objective: To impart knowledge about the biofuels, biofuels production, applications and their environmental effects

10. Course Outcomes: After completing this course, students would be able to

1. Describe the environmental sustainability of biofuels. Identify biomass composition and characteristics,
2. analyze reactions for the synthesis of biofuels.
3. Carry out biochemical conversions for the production of fuels.
4. Produce biodiesel.
5. Develop advanced technologies for bio-fuel production.

11. Details of Course

S. No.	Contents	Contact Hours
1	Generation of biofuels – Development of biological conversion technologies – Integration of biofuels into biorefineries – Energy security and supply – Environmental sustainability of biofuels -Economic sustainability of biofuels. Photosynthesis for Biofuels, Types of biomass and available resources, Lignocellulosic biomass composition and characterizations	8
2	Pyrolysis, bio-oil upgradation, and biochar, Biomass gasification followed by Fischer-Tropsch synthesis for liquid fuels, Hydrothermal (sub- and supercritical water) technology for biofuels, Biopower, co-firing, biomass torrefaction and carbonization	8
3	Biochemical Conversion Process, bioethanol production from 1st and 2nd generation biomass feedstock, Bioethanol – Properties – Feedstocks – Process technology – Pilot plant for ethanol production from lignocellulosic feedstock – Environmental aspects of ethanol as a biofuel. biohydrogen, and methane,	10
4	Biodiesel – Properties – Feed stocks – Process technology – Pilot plant for Biodiesel production– Environmental aspects of biodiesel as a biofuel.	8
5	Advance biofuel technologies, Algae to biofuels and challenge, Biobased products, life cycle analysis, and water use in biofuels, Biofuels economics, policies, and future R&D	8

Suggested Books

S. No.	Name of Books/Authors/Publisher	Year of Publication /Reprint
1	Biorenewable Resources: Engineering New Products from Agriculture/ R.C.Brown/ Wiley-Blackwell.	2014
2	Gasoline, Diesel and Ethanol Biofuels from Grasses and Plants/ R.B. Gupta and A. Demirbas/ Cambridge University Press	2012
3	Biofuels Engineering Process Technology/ C. Drapcho, J. Nghiem, T. Walker/ McGraw Hill Publications.	2008

1. Subject Code: **CH428** Course Title: **Energy Conservation and Recycling**
2. Contact Hours: L: 03 T: 01 P: 00
3. Examination Duration (Hrs.): Theory: 03 Practical: 00
4. Relative Weight: CWS: 25 PRS: 00 MTE: 25 ETE: 50 PRE: 00
5. Credits: 04
6. Semester: EVEN-VIII
7. Subject Area: DEC/GEC
8. Pre-requisite: NIL
9. Objective: To make student understand about the conservation of energy and energy efficiency, recycling and economics.
10. Course Outcomes: After completing this course, students would be able to

1. Describe the importance of energy conservation, its benefits and requirements.
2. Apply the laws/rules of thermodynamics to explain the mechanism of energy thermal and mechanical energy conservation.
3. Develop and design the different thermal and mechanical energy conservation, storage and recycling devices.
4. Evaluate the heat loss in different mechanical or civil systems and identify the methods to prevent it.
5. Evaluate the benefit of energy conversation/recycling in economic point of view for various cases.
6. Analyse different case studies problems and design specific energy conversation/recycling processes/equipment for them, and evaluate them economically.

11. Details of Course

S. No.	**Content**	**Contact Hours**
1.	Energy Conservation, Approach and modern Techniques, Benefits, Trends.	4
2.	Techno-Economic evaluation of conservation technologies, Efficiency Improvements, Thermal Utilities, Thermic fluid heating systems, Furnaces, Heating and melting applications, Refractories, Energy conservation in energy intensive chemical and process industries like pulp and paper, cement, sugar & petrochemical, fertilizer industries.	10

3.	Sources of waste heat and its utility, Heat recovery systems (Recuperates, Regenerator, Thermal or Heat wheels, Heat pipes and Heat pumps, etc.), Efficient steam generation fluidized bed boilers, Efficient use of steam traps condensate collections and return, Steam and gas turbine, Cogeneration, Heat exchanger network synthesis, Process heat recovery and recycling.	8
4.	Energy efficiency in buildings & ECBC, Envelop heat loss and heat gain and its evaluation, Opportunities and techniques for energy conservation in buildings, Adoption to sustainable resources, Process and technologies, Green buildings, Intelligent buildings, Rating of buildings.	6
5	Energy storage in conventional and non-conventional energy systems, Technical aspects, Various forms of energy storage and Techno commercial analysis (Economical aspects) thereof.	8
6	Energy economics, Thermal energy conservation, Case studies of commercial/industrial/residential energy conservation systems and their economical analysis.	6

Suggested Books

S. No.	Name of Books/Authors/Publisher	Year of Publication /Reprint
1	Energy Conservation and Management/ S. S. Thipse/ Alpha Science International Limited	2014
2	Energy Conservation in the Process Industries/ W.F. Kenney/ Academic Press.	2012
3	Handbook of Recycling: State-of-the-art for Practitioners, Analysts, and Scientists/ E. Worrell, M. Reuter/ Elsevier	2014
4	WEEE Recycling: Research, Development, and Policies/ A. Chagnes, G. Cote/ Elsevier.	2016