B. Tech.

IN

Chemical Engineering

CURRICULUM

DEPARTMENT OF CHEMICAL ENGINEERING
NATIONAL INSTITUTE OF TECHNOLOGY
CALICUT 673601
KERALA, INDIA

Vision

To be a global leader in chemical engineering education, creating well qualified engineers of high caliber who can contribute to their profession and are equipped with necessary traits to handle future technological challenges pertaining to chemical engineering and allied fields.

Mission

- Offer high quality education in scientific and engineering aspects of chemical engineering.
- Impart engineering and research skills to the students to make them innovative and competitive with the changing needs of industry and environment.
- Create awareness of social responsibilities in students to serve the society.

The Program Educational Objectives (PEOs) of B. Tech. in Chemical Engineering

PEO1	**Practice chemical engineering in traditional and emerging fields.**
PEO2	**Excel in advanced studies with strong foundation laid in the under graduate education.**
PEO3	**Exhibit leadership, ethical attitude, communication skills, teamwork in their profession and multidisciplinary skills.**
PEO4	**Engage in lifelong learning and continuous professional development.**

The Programme Outcomes (POs) of B. Tech. in Chemical Engineering

PO1	**Graduates will demonstrate the knowledge of Mathematics, Basic Sciences and Chemical Engineering.**
PO2	**Graduates will attain an ability to identify, formulate and solve Chemical Engineering problems.**
PO3	**Graduates will develop an ability to design and conduct tests/experiments in the various domains related to Chemical engineering and interpret the results.**
PO4	**Graduates will be able conduct investigations of complex problems in Chemical engineering using research based knowledge and research methods.**
PO5	**Graduates will exhibit skills to use modern engineering tools, software and equipment to analyze various problems in the Chemical Engineering domain.**
PO6	**Graduates will be aware of their professional and ethical responsibilities.**
PO7	**Graduates will be able to work individually or as a team member or leader in uniform and multidisciplinary settings.**
PO8	**Graduates will be able to communicate effectively in both verbal and written forms.**
PO9	**Graduates will understand the impact of engineering solutions on the society and will also be aware of contemporary issues.**
PO10	**Graduates will develop confidence for self-education and ability for lifelong learning.**
PO11	**Graduates will appear and succeed in competitive examinations, for pursuing higher studies in Chemical Engineering or other related multidisciplinary fields.**
PO12	**Graduates will have an understanding of engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects.**

CURRICULUM

The total minimum credits for completing the B. Tech. programme in chemical engineering is160.

MINIMUM CREDIT REQUIREMENT FOR THE VARIOUS COURSE CATEGORIES

The structure of B.Tech. programmes shall have the following Course categories:

Sl. No.	COURSE CATEGORY	Number of Courses	Credits
1.	Mathematics (MA)	4	12
2.	Science (BS)	5	10
3.	Humanities (HL)	3	9
4.	Basic Engineering(BE)	6	15
5.	Professional Core (PC)	30	84
6.	Open Electives (OE)	2	6
7.	Departmental Electives (DE)	6	18
8.	Other Courses (OT)	4	6
	TOTAL	60	160

COURSE REQUIREMENTS

1. MATHEMATICS

Sl.No.	Course Code	Course Title	L	T	P	Credits
1.	MA1001D	Mathematics I	3	1	0	3
2.	MA1002D	Mathematics II	3	1	0	3
3.	MA2001D	Mathematics III	3	1	0	3
4.	MA2002D	Mathematics IV *	3	1	0	3
		Total	12	4	0	12

* Mathematics IV will be branch specific.

2. SCIENCE

Sl.No.	Course Code	Course Title	L	T	P	Credits
1.	PH1001D	Physics	3	0	0	3
2.	PH1091D	Physics Lab	0	0	2	1
3.	CY1001D	Chemistry	3	0	0	3
4.	CY1094D	Chemistry Lab	0	0	2	1
5.	BT1001D	Introduction to Life Science	2	0	0	2
		Total	8	0	4	10

3. HUMANITIES

Sl.No.	Course Code	Course Title	L	T	P	Credits
1.	MS1001D	Professional Communication	3	0	0	3
2.	MS3001D	Engineering Economics	3	0	0	3
3.	ME3104D	Principles of Management	3	0	0	3
		Total	9	0	0	9

4. BASIC ENGINEERING

Sl.No.	Course Code	Course Title	L	T	P	Credits
1.	ZZ1001D	Engineering Mechanics	3	0	0	3
2.	ZZ1003D	Basic Electrical Sciences	3	0	0	3

3.	ZZ1002D	Engineering Graphics	2	0	2	3
4.	ZZ1004D	Computer Programming	2	0	0	2
5.	ZZ1091D	Workshop I	0	0	3	2
6.	ZZ1092D	Workshop II	0	0	3	2
		Total	10	0	8	15

5. OTHER COURSES (OT)

Sl.No.	Course Code	Course Title	L	T	P	Credits
1.	ZZ1093D	Physical Education	0	0	2	1
2.	ZZ1094D	Value Education	0	0	2	1
3.	ZZ1095D	NSS	0	0	2	1
4.	CH3005D	Environmental Studies	3	0	0	3
		Total	3	0	6	6

6. PROFESSIONAL CORE

Sl.No	Course Code	Course Title	Prerequisites	L	T	P	Credits
1.	CY2001D	Physical Chemistry		3	0	0	3
2.	CH2001D	Chemical Technology		3	0	0	3
3.	CH2002D	Process Calculations		3	0	0	3
4.	CH2003D	Fluid Mechanics		3	0	0	3
5.	CH2004D	Mechanical Operations		3	0	0	3
6.	CH2091D	Chemical Analysis Laboratory		0	0	3	2
7.	CY2002D	Organic Chemistry		3	0	0	3
8.	CH2005D	Chemical Engineering Thermodynamics I		3	0	0	3
9.	CH2006D	Heat Transfer		3	0	0	3
10.	CH2007D	Process Instrumentation		3	0	0	3
11.	CH2008D	Material Science		3	0	0	3
12.	CH2092D	Fluid Mechanics Laboratory	CH2003D	0	0	3	2

13.	CH2093D	Mechanical Operations Laboratory		0	0	3	2
14.	CH3001D	Chemical Engineering Thermodynamics II	CH2005D	3	0	0	3
15.	CH3002D	Mass Transfer I		3	0	0	3
16.	CH3003D	Chemical Reaction Engineering I		3	0	0	3
17.	CH3004D	Process Dynamics and Control		3	0	0	3
18.	CH3091D	Heat Transfer Laboratory	CH2006D	0	0	3	2
19.	CH3006D	Mass Transfer II	CH3002D	3	0	0	3
20.	CH3007D	Chemical Process Equipment Design	CH2006D, CH3006D	4	0	0	4
21.	CH3008D	Chemical Reaction Engineering II	CH3003D	3	0	0	3
22.	CH3092D	Process Dynamics and Control Laboratory	CH3004D	0	0	3	2
23.	CH4001D	Transport Phenomena	CH3003D, CH3006D	3	0	0	3
24.	CH4002D	Computer Applications in Chemical Engineering		2	0	2	3
25.	CH4003D	Process Optimization		3	0	0	3
26.	CH4091D	Mass Transfer Laboratory	CH3006D	0	0	3	2
27.	CH4092D	Chemical Reaction Engineering Laboratory	CH3008D	0	0	3	2
28.	CH4093D	Project: Part 1		0	0	4	2
29.	CH4094D	Seminar		0	0	3	1
30.	CH4095D	Project: Part 2	CH4093D	0	0	12	6
Total				60	0	42	84

7. DEPARTMENT ELECTIVES

Sl.No.	Course Code	Course Title	Prerequisites	L	T	P	Credits
1.	CH 3021D	Energy Technology		3	0	0	3
2.	CH 3022D	Petroleum Refining Operations and Processes		3	0	0	3
3.	CH 3023D	Corrosion Engineering		3	0	0	3
4.	CH 3024D	Polymer Technology		3	0	0	3
5.	CH 3025D	Food Technology		3	0	0	3
6.	CH 3026D	Ceramic Technology		3	0	0	3
7.	CH 3027D	Biotechnology		3	0	0	3
8.	CH 3028D	Fertilizer Technology		3	0	0	3
9.	CH 3029D	Operations Research		3	0	0	3
10.	CH 3030D	Human Resource Management		3	0	0	3
11.	CH 3031D	Drugs and Pharmaceutical Technology		3	0	0	3
12.	CH3032D	Colloid and Interface Science		3	0	0	3
13.	CH 3033D	Professional Ethics & Human Values		3	0	0	3
14.	CH 4021D	Biochemical Engineering		3	0	0	3
15.	CH 4022D	Electrochemical Engineering		3	0	0	3
16.	CH 4023D	Environment Impact Assessment and Clean Technology		3	0	0	3
17.	CH 4024D	Process Automation	CH3004D	3	0	0	3
18.	CH 4025D	New Enterprises Creation and Management		3	0	0	3
19.	CH 4026D	Speciality Polymers		3	0	0	3
20.	CH 4027D	Process Modelling and Simulation	CH3007D	3	0	0	3
21.	CH 4028D	Membrane Technology		3	0	0	3

22.	CH 4029D	Mathematical Methods in Chemical Engineering		3	0	0	3
23.	CH 4030D	Computational fluid dynamics	CH2003D, CH2006D	3	0	0	3
24.	CH 4031D	Micro Electronics Processing		3	0	0	3
25.	CH 4032D	Risk Analysis and Hazop		3	0	0	3
26.	CH 4033D	Novel Separation Techniques		3	0	0	3
27.	CH 4034D	Project Engineering		3	0	0	3
28.	CH 4035D	Fuel Cells		3	0	0	3
29.	CH 4036D	Composite Materials		3	0	0	3
30.	CH 4037D	Safety in Chemical Industries		3	0	0	3
Total				90	0	0	90

8. OPEN ELECTIVES

Two elective courses to be credited from other departments.

Course Structure

Semester I

Sl. No	Course Code	Course Title	L	T	P	Credits	Category
1.	MA1001D	Mathematics I	3	1	0	3	MA
2.	PH1001D/CY1001D	Physics/Chemistry	3	0	0	3	BS
3.	MS1001D/ ZZ1003D	Professional Communication/ Basic Electrical Sciences	3	0	0	3	HL/BE
4.	ZZ1001D/ ZZ1002D	Engineering Mechanics/ Engineering Graphics	3/2	0	0/2	3	BE
5.	ZZ1004D/BT1001D	Computer Programming / Introduction to Life Science	2	0	0	2	BE/BS
6.	PH1091D/CY1094D	Physics Lab/ Chemistry Lab	0	0	2	1	BS
7.	ZZ1091D/ ZZ1092D	Workshop I/Workshop II	0	0	3	2	BE
8.	ZZ1093D/ZZ1094D/ZZ1095D	Physical Education /Value Education/ NSS	-	-	-	3*	OT
	Total Credits		14/12	1	5/8	17+3*	

*Note: Three courses of 1 credit each has to be credited within the first four semesters.

Semester II

Sl. No.	Course Code	Course Title	L	T	P	Credits	Category
1.	MA1002D	Mathematics II	3	1	0	3	MA
2.	CY1001D/PH1001D	Chemistry/ Physics	3	0	0	3	BS
3.	ZZ1003D/MS1001D	Basic Electrical Sciences/ Professional Communication	3	0	0	3	BS/HL
4.	ZZ1002D/ ZZ1001D	Engineering Graphics/ Engineering Mechanics	2/3	0	2/0	3	BE
5.	BT1001D/ ZZ1004D	Introduction to Life Science./Computer Programming	2	0	0	2	BS/BE
6.	CY1094D/PH1091D	Chemistry Lab / Physics Lab	0	0	2	1	BS
7.	ZZ1092D/ ZZ1091D	Workshop II/ Workshop I	0	0	3	2	BE
	Total Credits		12/14	1	8/5	17	

Semester III

Sl. No.	Course Code	Course Title	L	T	P	Credits	Category
1	MA2001D	Mathematics III	3	1	0	3	MA
2	CY2001D	Physical Chemistry	3	0	0	3	PC
3	CH2001D	Chemical Technology	3	0	0	3	PC
4	CH2002D	Process Calculations	3	0	0	3	PC
5	CH2003D	Fluid Mechanics	3	0	0	3	PC
6	CH2004D	Mechanical Operations	3	0	0	3	PC
7	CH2091D	Chemical Analysis Laboratory	0	0	3	2	PC
	Total Credits		18	1	3	20	

Semester IV

Sl. No.	Course Code	Course Title	L	T	P	Credits	Category
1	MA2002D	Mathematics IV	3	1	0	3	MA
2	CY2002D	Organic Chemistry	3	0	0	3	PC
3	CH2005D	Chemical Engineering Thermodynamics I	3	0	0	3	PC
4	CH2006D	Heat Transfer	3	0	0	3	PC
5	CH2007D	Process Instrumentation	3	0	0	3	PC
6	CH2008D	Material Science	3	0	0	3	PC
7	CH2092D	Fluid Mechanics Laboratory	0	0	3	2	PC
8	CH2093D	Mechanical Operations Laboratory	0	0	3	2	PC
	Total Credits		18	1	6	22	

Semester V

Sl. No.	Course Code	Course Title	L	T	P	Credits	Category
1	ME3104D	Principles of Management	3	0	0	3	HL
2	CH3001D	Chemical Engineering Thermodynamics II	3	0	0	3	PC
3	CH3002D	Mass Transfer I	3	0	0	3	PC
4	CH3003D	Chemical Reaction Engineering I	3	0	0	3	PC
5	CH3004D	Process Dynamics and Control	3	0	0	3	PC
6	CH3005D	Environmental Studies	3	0	0	3	OT
7		Elective I	3	0	0	3	DE/OE
8	CH3091D	Heat Transfer Laboratory	0	0	3	2	PC
	Total Credits		21	0	3	23	

Semester VI

Sl. No.	Course Code	Course Title	L	T	P	Credits	Category
1	MS3001D	Engineering Economics	3	0	0	3	HL
2	CH3006D	Mass Transfer II	3	0	0	3	PC
3	CH3007D	Chemical Process Equipment Design	4	0	0	4	PC
4	CH3008D	Chemical Reaction Engineering II	3	0	0	3	PC
5		Elective II	3	0	0	3	DE/OE
6		Elective III	3	0	0	3	DE/OE
7	CH3092D	Process Dynamics and Control Laboratory	0	0	3	2	PC
	Total Credits		19	0	3	21	

Semester VII

Sl. No.	Course Code	Course Title	L	T	P	Credits	Category
1	CH4001D	Transport Phenomena	3	0	0	3	PC
2	CH4002D	Computer Applications in Chemical Engineering	2	0	2	3	PC
3	CH4003D	Process Optimization	3	0	0	3	PC
3		Elective IV	3	0	0	3	DE/OE
4		Elective V	3	0	0	3	DE/OE
5	CH4091D	Mass Transfer Laboratory	0	0	3	2	PC
8	CH4092D	Chemical Reaction Engineering Laboratory	0	0	3	2	PC
7	CH4093D	Project: Part 1	0	0	4	2	PC
8	CH4094D	Seminar	0	0	3	1	PC
	Total Credits		14	0	15	22	

Semester VIII

Sl. No.	Course Code	Course Title	L	T	P	Credits	Category
1		Elective VI	3	0	0	3	DE/OE
2		Elective VII	3	0	0	3	DE/OE
3		Elective VIII	3	0	0	3	DE/OE
4	CH4095D	Project: Part 2	0	0	12	6	PC
	Total Credits		9	0	12	15	

Notes:

1. For the successful completion of B.Tech programme, a student must complete the minimum number of courses of each category specified in the curriculum of the specific programme. In addition to the above, the student must have acquired a total of 160 credits.
2. A student who completes all the course requirements (except the project) before the final semester may be permitted to undertake project at an institute/industry outside with the consent of the department.

SEMESTER	CREDITS
I	17+3
II	17
III	20
IV	22
V	23
VI	21
VII	22
VIII	15
TOTAL	**160**

MA2001D MATHEMATICS III

L	T	P	C
3	1	0	3

Pre-requisites: Nil

Total hours: 39

Course Outcomes:

Students will be able to:

CO1: Handle application problems involving random variables and functions of random variables.

CO2: Identify statistical problems and make use of statistical inference while handling stochastic systems.

CO3: Apply regression and correlation analysis for studying relationship between variables.

CO4: Identify situations where analysis of variance is appropriate and apply it.

CO5: Use probabilistic and statistical analysis in various applications of engineering.

Module 1: (15 Hours)

Probability distributions, Random variables, Expectation of a function of a random variable, Mean, Variance and Moment generating function of a probability distribution, Chebyshev's theorem, Binomial distribution, Poisson distribution, Geometric distribution, Hyper- geometric distribution, Normal Distribution, Uniform distribution, Gamma distribution, Beta distribution and Weibull distribution. Transformation of a random variable, Probability distribution of a function of a random variable, Jointly distributed random variables, Marginal and conditional distributions,Bi-variate Normal distribution, Joint probability distribution of functions of random variables**.**

Module 2: (14 hours)
Population and samples, The sampling distribution of the mean (σ known and σ unknown), Sampling distribution of the variance, Point estimation, Maximum likelihood estimation, Method of moments,Interval estimation, Point estimation and interval estimation of mean and variance. Tests of hypothesis, Hypothesis tests concerning one mean and two means. Hypothesis tests concerning one variance and two variances, Estimation of proportions, Hypothesis tests concerning one proportion and several proportions, Analysis of $r \times c$ contingency tables, Chi – square test for goodness of fit.

Module 3: (10 hours)
Analysis of variance, General principles, completely randomized designs, Randomized block design. Curve fitting, Method of least squares, Estimation of simple regression models and hypotheses concerning regression coefficients, Correlation coefficient- Estimation of correlation coefficient, Hypothesis concerning correlation coefficient. Estimation of curvilinear regression models.

References:

1. R. A. Johnson, Miller and Freund's Probability and Statistics for Engineers, 8th edition., PHI, New Delhi, 2011.
2. W. W. Hines, D. C. Montgomery, D. M. Goldsman and C. M. Borror, Probability and Statistics in Engineering, 4th edition, John Wiley & Sons, Inc., 2003
3. S.M. Ross, Introduction to Probability and statistics for Engineers and Scientists, 5rd edition, Academic Press (Elsevier), New Delhi, 2014

CY2001D PHYSICAL CHEMISTRY

Pre-requisites: Nil

L	T	P	C
3	0	0	3

Total hours: 39

Course Outcomes:

CO 1: Student should be able to apply the fundamental thermodynamic principles and their application to engineering problems.

CO 2: Student should be able to deliver the fundamentals of reactions kinetics.

CO 3: Student should be able to deliver the principles about the interaction of light with molecules, identification and characterization of chemical species.

Module 1: (14 hours)

Concept of free energy and entropy – The Helmholtz and Gibbs energies – Criteria for spontaneity, Properties of the internal energy, The Maxwell relations, Properties of Helmoltz and Gibbs free energy– Variation of free energy with pressure and temperature-Gibbs Helmholtz equation- application in electrochemical cell, conditions for equilibrium – Derivation of Law of Chemical equilibrium from thermodynamics – Van't Hoff reaction isotherm, Relation between K_p, K_c and K_x, Ellingham diagrams and extraction of metals, Thermodynamics of solutions – Partial molar quantities, Chemical potential, Colligative properties- Van't Hoff Factor. Gibbs Phase Rule– Conditions for equilibrium between phases, Clapeyron- Clausius equation, One component system – Water- metastable equilibrium, triple point, Two component system- simple eutectic systems, cooling curves, (eg. Pb-Ag),Three component solid-liquid systems.

Module 2: **(13 hours)**

Rate of reaction, order and molecularity, rate laws and rate constants– integration of rate expression of first, second and n^{th} order reactions, Half life time of a reaction, The temperature dependence of reaction rates. Theories of reaction rates – Collision theory and Activated complex theory of bimolecular gaseous reactions.The Lindemann – Hinshelwood mechanism of unimolecular reactions. Kinetics of opposing, consecutive, parallel reactions (first order examples) – Steady state approximation, Chain reactions:H_2–Cl_2, H_2–Br_2 and H_2–O_2 reaction, Polymerization kinetics – Stepwise polymerization, Chain polymerization.Electrocatalysis - mechanism, Kinetics of electrode reactions- Butler – Volmer and Tafel equations.

Module 3: (12 hours)

Consequences of light Absorption, Laws of Photochemistry–Grotthus-Draper Law, Stark–Einstein law of Photochemical equivalence, Quantum Yield- determination, Photochemical rate law, Photosensitization, Quenching of Fluorescence, Chemiluminescence. Principles of Raman Spectroscopy, NMR Spectroscopy–^{1}H NMR, Electron spin resonance spectroscopy.

References:

1. P.W.Atkins and J.D.Paula, Atkins' Physical Chemistry (Eighth Edition). New York: Oxford University Press, 2006.
2. I. N. Levine, Physical Chemistry (Sixth Edition). New Delhi: Tata McGraw-Hill, 2009.
3. K. J. Laidler, Chemical Kinetics (Third Edition). New Delhi: Pearson Education, 2004.

4. G. K. Vemulapalli, Physical Chemistry. New Delhi: Prentice Hall, 2004.
5. B.R. Puri, L.R.Sharma, M.S. Pathania, Principles Physical Chemistry (46^{th} edition). New Delhi: Vishal Publishing Co., 2015.
6. J.O'M. Bockris and A. K. N. Reddy, Modern Electrochemistry 2A, New York: Kluwer Academic Publishers, 1998.
7. C. N. Banwell and E. M. McCash, Fundamentals of Molecular Spectroscopy, (4^{th} edition), New Delhi: Tata McGraw Hill, New Delhi, 2010

CH2001D CHEMICAL TECHNOLOGY

Prerequisite: Nil

L	T	P	C
3	0	0	3

Total hours: 39

Course outcomes:

CO1:Write about the Indian Chemical Industry

CO2:Draw process flow diagrams and explain the manufacturing processes of various chemical industries

CO3:List out the raw materials and write the relevant chemical reactions for industrial chemical manufacturing

Module 1 (13hours)

Indian chemical industry: An overview.
Study of following chemical industries with reference to process technology, availability of raw materials, preparation of flow sheet, production trends and future prospects, pollution and major engineering problems:
Chloro-alkali industries: Caustic soda; Chlorine; Hydrochloric acid; Bleaching powder; Soda ash.
Sulphur and sulphuric acid: Sulfur, sulfuric acid, SCSA and DCDA processes; Sodium thiosulfate;Alums.
Cement industries
Paints and pigments.

Module 2 (13 hours)

Fertilizers and other chemicals: Ammonia; Urea; Calcium ammonium nitrate; Nitric acid; Phophoricacid; Phosphatic and other fertilizers- super phosphate and triple super phosphate,NPK, MAP, DAP, potassium fertilizers and nitrophosphates; Biofertilizers.
Soaps and detergents, glycerine manufacture,
oils and fats- expression, solvent extraction, hydrogenation of oils,

Module 3 (13 hours)

Sugar and starchindustries
Manufacture of pulp, paper and paperboards,
fermentation industries, industrial alcohol, absolute alcohol, beers, wines.
Fuel and industrial gases
Petrochemicals: methanol, vinylchloride, ethylene oxide, isopropanol, butadiene, phenol and phthalic anhydride
Polymers, production of thermoplastic and thermosetting materials such as polyethylene, polypropylene, phenolic resins and epoxy resins

Reference

1. George T Austin, Shreve's Chemical Process Industries- International Student Edition, 5thEdn., McGraw Hill Inc., 1985.

2. GopalRao, R. and Sittig, M., Dryden's Outlines of Chemical Technology, 3rdEdn, Affiliated East-West Publishers, 1997.
3. Shukla, S.D. and Pandey, G.N., Text book of Chemical Technology, Vol.I, 1977.
4. Jacob A. Moulijn, MichielMakkee and Annelies van Diepen , Chemical Process Technology, 1stEdn, 2001.

CH2002D PROCESS CALCULATIONS

Prerequisite: Nil

L	T	P	C
3	0	0	3

Total hours: 39

Course outcomes:

CO1:Understand the units of measurements and properties in different system of units and their conversion of from one system to another

CO2: Quantify the mass in mole and vice versa

CO3: Apply the equation of state to characterize the properties of gas mixtures and quantify the humidity of vapors in non-condensable gases and accompanying calculations

CO4: Learn the components of material and energy balances with and without chemical reaction

CO5:Find excess and limiting reactants, conversion yield etc.

CO6: Formulate the energy balance in closed and open systems and calculate the heat accompanying the chemical reactions

Module 1 (12 hours)

Introduction, dimensional consistency, conversion of units, mole concept and mole fraction, weight fraction and volume fraction, concentration of liquid solutions, molarity, molality, normality, ppm, density and specific gravity, composition relationships, ideal gases and gas mixtures, real gases, vapour pressure, vapour liquid equilibrium, humidity and saturation.

Module 2 (14 hours)

General material balance equation- simplifications for steady-state processes without chemical reaction, element balance, material balance problems involving multiple subsystems, recycle, bypass and purge calculations, Material balance problems with chemical reactions, concept of limiting, excess reactants, fractional conversion and percentage of conversion, percentage yield.

Module 3 (13 hours)

Orsat analysis, ultimate and proximate analysis of coal, material balance problems involving simultaneous equations,Energy balance, heat capacity, estimation of heat capacities, calculation of enthalpy changes (without phase change), enthalpy change for phase transitions, thermochemistry, heat of formation, reaction, combustion, Hess's law of summation, theoretical flame temperature

Reference

1. Narayanan K.V, and Lakshmikuttyamma, B., Stoichiometry & Process Calculations, 2ndEdn., Prentice Hall Publishing, 2016.
2. Himmelblau, D.H, Basic Principles and Calculations in Chemical Engineering, 8thEdn., Prentice Hall, New York, 2012.

3. Bhatt B.I, and Thakore S. B,, Stoichiometry, 5th Edn., Tata McGraw-Hill Publishing Company Ltd., 2011.
4. Hougen, O.A, Watson, K.M and Ragatz R.A, Chemical Processes Principles (Part-1): Material and Energy Balances, 2nd Edn, Asia Publication House, New Delhi, 2001.
5. Felder, R.M. and Rousseau, R.W., Elementary Principle and Chemical Processes, 3rd Edn, John Wiley & Sons Inc., 2008.

CH2003DFLUID MECHANICS

Pre-requisites: Nil

L	T	P	C
3	0	0	3

Total hours: 39

Course Outcomes:

CO1: Able to understandthebasic laws andtheequations governing fluid flows.

CO2: Calculate theheadlosses in pipe flows and chemical engineering systems.

CO3: Choose the right fluid measurement devices and pumps for the required applications

Module 1: (13 hours)

Introduction, basic fluid concepts, Newtonian and non-Newtonian fluids, fluid kinematics – flow patterns and flow visualization, vorticity and rotationally, Reynolds transport theorem, continuity equation, Navier-Stokes equations, momentum balance, introduction to turbulence.

Module 2: (14 hours)

Boundary layer theory (Laminar), Bernoulli's equation, correction for fluid friction, correction for pump work, flow of incompressible fluids in pipes, laminar and turbulent flow through closed conduits, velocity profile and friction factor for smooth and rough pipes, head loss due to friction in pipes, fittings etc., flow of fluids through solids, form drag, skin drag, drag coefficient, flow around solids and packed beds, friction factor for packed beds, Ergun's equation, motion of particles through fluids, motion under gravitational and centrifugal fields, fluidization, mechanism, types, general properties, applications.

Module 3: (12 hours)

Dimensional analysis and similitude, measurement of fluid flow - orifice meter, venture meter, pilot tube, transportation of fluids- fluid moving machinery performance, selection and specification, positive displacement pumps, rotary and reciprocating pumps, centrifugal pumps and characteristics, calculation of NPSH.

References:

1. McCabe, W.L., Smith,J.C. and Peter H., Unit Operations of Chemical Engineering, 7th edition, McGraw-Hill, New York, 2014.
2. Cengel, Y.A. and John M. Cimbala, Fluid Mechanics – Fundamentals and Applications – 3rd Edition, McGraw-Hill, NY, 2013
3. De Nevers N H, Fluid Mechanics for Chemical Engineers - 3rdEdition, McGraw-Hill, NY, 2004.
4. Fox, R. W., McDonald, A. T., Pritchard, P. J., and Mitchell J. W., Fluid Mechanics, 9thEdn, Wiley, 2015

CH2004D MECHANICAL OPERATIONS

Pre-requisites: Nil

L	T	P	C
3	0	0	3

Total hours: 39

Course Outcomes:

CO1: Understand basic principles of particles preparation and their characterization

CO2: Determine the crushing efficiency of different size reduction equipment's using crushing laws

CO3: Acquire knowledge on different mixing and blending equipment's.

CO4: Select the appropriate equipment for particle separation

CO5: Design of filtration, sedimentation and cyclone separators

Module 1 (13 hours)

Properties and handling of particulate solids, characterization of solid particles, standard screen series, particle size and screen analysis, Properties of particulate masses, pressure in masses of particles. Size reduction, principles of comminution- Rittinger's law, Kick's law, Bond's crushing law and work index, particle size distribution in comminuted products, energy and power requirements in comminution, size reduction equipment- crushers, grinders, ultrafine grinders ,jaw crusher, gyratory crusher, smooth roll crusher, roller mills, attrition mills, revolving mills, fluid energy mills), Mechanical separations, screening, comparison of ideal and actual screens, capacity and effectiveness of screens

Module 2 (13 hours)

Particle separation methods : filtration, principles of cake filtration, pressure drop through filter cake, filter medium resistance, constant pressure filtration, constant rate filtration, continuous filtration, filter aids, washing of filter cakes, equipment of liquid-solid separation - separations based on the motion of particles through fluids, centrifugal filtration, gravity settling processes, batch sedimentation, differential settling methods, centrifugal settling processes, centrifugal decanters, cyclone separation,

Module 3 (13 hours)

Agitation and mixing of liquids, agitation equipment's, power consumption in agitated vessels, mixing of solids and paste, types of mixers- Magnetic separation, electrostatic separation, jigging, heavy media separation, froth floatation process, flocculation, briquetting, pelletization and granulation. Conveying methods, Storage methods and design of silo, bins and hoppers, selection of feeders and elevators

Reference

1. McCabe, W.L. and Smith, J.C., Unit Operation of Chemical Engineering, 5th Edition., McGraw Hill, New York, 1993.

2. Coulson, J.M. and Richardson, J.F., Chemical Engineering, Vol. II, 4th Edition., Butterworth - Heinemann, 1991.
3. Raymond A. K., Materials Handling Handbook, 2nd Edition., Wiley-Interscience Publications, 1985.
4. Badger and Banchero, Introduction to Chemical Engineering, 1st Edition., McGraw Hill, NewYork, 1954.

CH2091D CHEMICAL ANALYSIS LABORATORY

Pre-requisites: Nil

L	T	P	C
0	0	3	2

Lab Outcomes

Able to :

CO1: Determine the water pollutants quantitatively and qualitatively

CO2: Analyze the water and wastewater samples

CO3: Analyze the oil properties

CO4: Estimate the quality of soap and bleaching powder

List of experiments:

1. Acid value, Iodine value and saponification value
2. Soap preparation and analysis
3. Flash, Fire and smoke point
4. Viscosity measurements.
5. Water analysis
6. Chemical oxygen demand and Biological oxygen demand
7. Growth curve of microorganisms
8. Analysis of dye and heavy metals in wastewater
9. Residual and break point chlorination
10. Separation of compounds using chromatographic techniques.

References:

1. R. Gopalan, D. Venkappayya and S. Nagarajan, Textbook of Engineering Chemistry, 4th Edition, Vikas Publishing House

2. C. S. Rao, Environmental Pollution Control Engineering, 2nd Edition, New Age International, 2006

MA2002D MATHEMATICS IV

Pre-requisites: Nil

Total hours: 39

L	T	P	C
3	1	0	3

Course Outcomes: Students will be able to

CO1: Find solutions of linear differential equations using power series method and Frobenius series method.

CO2: Formulate various engineering problems as partial differential equations and hence solve them.

CO3: Identify analytic functions and find harmonic conjugates.

CO4: Find images of regions under complex transformations.

CO5: Evaluate line integrals in the complex plane

CO6: Use techniques of complex analysis to evaluate integrals of real valued functions.

Module 1:Series Solutions and Special Functions (11 Hours)

Power series solutions of differential equations, Theory of power series method, Legendre Equation, Legendre Polynomials, Frobenius Method, Bessel's Equation, Bessel functions, Bessel functions of the second kind, Sturm- Liouville's Problems, Orthogonal eigenfunction expansions.

Module 2: Partial differential Equations (10 Hours)

Basic Concepts, Cauchy's problem for first order equations, Linear Equations of the first order, Nonlinear Partial Differential Equations of the first order, Charpit's Method, Special Types of first order equations, Classification of second order partial differential equations, Modeling: Vibrating String, Wave equation, Separation of variables, Use of Fourier Series, D'Alembert's Solution of the wave equation, Heat equation: Solution by Fourier series, Heat equation: solution by Fourier Integrals and transforms, Laplace equation, Solution of a Partial Differential Equations by Laplace transforms.

Module 3: Complex Numbers and Functions (9 Hours)

Complex functions, Derivative , Analytic function, Cauchy- Reimann equations, Laplace's equation, Geometry of Analytic functions: Conformal mapping, Linear fractional Transformations, Schwarz - Christoffel transformation, Transformation by other functions.

Module 4: Complex Integration (9 Hours)

Line integral in the Complex plane, Cauchy's Integral Theorem, Cauchy's Integral formula, Derivatives of analytic functions.Power series, Functions given by power series, Taylor series and Maclaurin's series.Laurent's series, Singularities and Zeros, Residue integration method, Evaluation of real Integrals.

References:

1. Kreyszig E, Advanced Engineering Mathematics, 8th Edition, John Wiley & Sons, New York, 1999 .
2. I.N. Sneddon, Elements of Partial Differential Equations, Dover Publications, 2006.
3. Wylie C. R. &Barret L. C., Advanced Engineering Mathematics, 6th Edition, McGraw Hill, NewYork,1995.
4. Donald W. Trim, Applied Partial Differential Equations, PWS – KENT publishing company, 1994.

CY2002D ORGANIC CHEMISTRY

Pre-requisites: Nil

L	T	P	C
3	0	0	3

Total hours: 39

Course Outcomes: Student should be able to

CO1:Apply the principles of organic stereochemistry

CO2: Deliver the fundamental concepts of reaction mechanism

CO3: Deliver the principles and applications of organic synthesis

CO4: Deliver the methods of polymerization and polymer reactions

Module 1: (11 hours)

Concept of chirality and molecular dissymmetry, recognition of symmetry elements and chiral centers,projection formulae and their interconversions,prochiral relationship, homotopic, enantiotopic and diasteriotopic groups and faces, racemic modifications, R and S nomenclature, geometrical isomerism, E and Z nomenclature, conformational analysis: cyclohexane derivatives, stability and reactivity, conformational analysis of disubstitutedcyclohexanes.

Module 2: (11 hours)

Definition of reaction mechanism, thermodynamic and kinetics data, substituent effects, linear free energy relationships, Hammett equation and related modifications, basic mechanistic concepts like kinetic vs thermodynamic control, Hammond postulate, Curtin-Hammett principle, isotope effects**, nucleophilic substitution**, stability and reactivity of carbocations, nucleophilicity and basicity, leaving group effect, steric effects in substitution reactions, classical and non-classical carbocations.

Module 3: (17 hours)

Functionalization of alkenes: hydroboration, dihydroxylation, epoxidation and oxidative cleavage. Oxidation: oxidation of hydrocarbons, alcohols and ketones. Reduction: catalytic hydrogenation, reduction by dissolving metals and reduction by hydride transfer reagents.Methods of polymerization:Radical chain polymerization, step polymerization: polycondensation, polyaddition, ring opening-lactams, lactones, electrochemical polymerization, group transfer polymerization, ion chain polymerization: cationic and anionic and emulsion polymerization.Molecular weight determination of polymers. Polymer reactions: hydrolysis, acidolysis, aminolysis, hydrogenation and cyclization.Cross linking: sulphur and peroxides. Stereochemistry of polymers

References:

1. T.W.G. Solomon and C.B. Fryhle. O*rganic Chemistry.*New York: Wiley, 2013.
2. R.T Morrison and R.N.Boyd.*OrganicChemistry.*NewJersey :PrenticeHall, 1992.
3. E.L. Eliel and S.H. Wilen.*Stereochemistry of Organic Compounds.*New York: Wiley, 1994.
4. P. Sykes.*A Guidebook to Mechanism in Organic Chemistry.* New York: Pearson Education, 2003.
5. R.O.C.Norman and J.M. Coxon.*Principles of Organic Synthesis.*UK :CRC Press, 1993.

6. W. Carruthers and I. Coldham, *Modern Methods of Organic Synthesis.* UK :Cambridge University Press, 2000.
7. J. March.*Advanced Organic Chemistry* :*Reactions, Mechanisms and Structure.* New York: Wiley, 2006.
8. F.A. Carey and R.J. Sundberg.*Advanced Organic Chemistry : Part A: Structure and Mechanisms.* New York : Springer, 2008.
9. F.A. Carey and R.J. Sundberg. *Advanced Organic Chemistry. Part B: Reactions and Synthesis.* New York : Springer, 2008.
10. O. Geroge.*Principles of Polymerization.* India : Wiley, 2008.
11. V.R. Gowariker, N.V. Viswanathan and J. Sreedhar.*PolymerScience.*India :New Age International, 2015.
12. K.J. Saunders.*Organic Polymer Chemistry :An Introduction to the Organic Chemistry of Adhesives, Fibres, Paints, Plastics and Rubbers.*London : Chapmann and Hall, 2012.

CH2005D CHEMICAL ENGINEERING THERMODYNAMICS I

Pre-requisite: Nil

L	T	P	C
3	0	0	3

Total hours: 39

Course Outcomes:

CO1: Write the definitions of important terms related to classical thermodynamics

CO2:Define the first law of thermodynamics and solve problems based on this law

CO3:Draw the thermodynamic phase diagrams and solve problems based on ideal and real gas concepts

CO4:Write the energy balance for open and closed systems and use it for solving problems

CO5:Define the second law. Describe in detail different thermodynamic cycles based on this law. Solve related numerical problems

Module 1 (14 hours)

Terminologies of thermodynamics – definitions and fundamental concepts, property, Energy, work, Zeroth law of thermodynamics, thermodynamic properties of fluids and their representation, Ideal gas law, equation of state, first law of thermodynamics – Joules experiment, Volumetric properties of fluids – PVT behavior of pure substances, PV diagram, critical behavior, single phase region,Virial equation of state, compressibility factor, Ideal gas, Equations for process calculations, Ideal gas, adiabatic process, polytropic process, irreversible process, applications of Virial equation of state, cubic equation of state, equation of state parameters and determinations, theory of corresponding states, generalized correlations for gases and liquids.

Module 2 (12 hours)

Energy balance for closed and open systems,Constant volume process, constant pressure process,Heateffects – sensible, temperature dependence, latent heat, heat of reaction, heat of formation, heat of combustion, temperature dependence of heat of reaction.

Module 3 (13 hours)

Second law of thermodynamics – statements, available and unavailable energies, entropy – calculation of entropy changes, applications of second law – refrigeration, flow processes and liquefaction processes, steam power cycles and internal combustion engine cycles, third law of thermodynamics, Entropy from microscopic point of view,Gibb's free energy, third law of thermodynamics, fundamental property relations, Fundamental property relations, Maxwell equations, calculation of property changes.

Reference

1. Van Ness, H.C, Abbott, M., Swihart, M., and Smith, J.M., Introduction to Chemical Engineering, Thermodynamics, 8thEdn, McGraw Hill, 2017.
2. Narayanan, K.V., A Textbook of Chemical Engineering Thermodynamics, 2ndEdn, Prentice Hall of India, 2013.
3. Kyle, B.G., Chemical and Process thermodynamics, 3rd Edn, Prentice Hall of India, 2006.

4. S.I. Sandler, Chemical, Biochemical and Engineering Thermodynamics, 4thEdn, Wiley India, 2006.
5. J.M. Prausnitz, R.N. Lichtenthaler and E.G. Azevedo, Molecular Thermodynamics of Fluid-Phase Equilibria, 3rd Edn, Prentice Hall, 1998.
6. J.W. Tester and M. Modell, Thermodynamics and its Applications, 3rdEdn, Prentice Hall, 1999.
7. R.C. Reid, J.M. Prausnitz and B.E. Poling, Properties of Gases and Liquids, 4thEdn, McGraw-Hill, 1987.
8. R. Balzheiser, M. Samuels, and J. Eliassen, Chemical Engineering Thermodynamics, Prentice Hall, 1972.
9. K. Denbigh, Principles of Chemical Equilibrium, 4thEdn, Cambridge University Press, 1981.

CH2006D HEAT TRANSFER

Pre-requisite: Nil

L	T	P	C
3	0	0	3

Total hours: 39

Course outcomes:

CO 1: Identify the different modes of heat transfer and calculate the rate of heat transfer

CO 2: Apply the concepts of one-dimensional; steady and unsteady state conduction heat transfer, and relevant boundary and initial conditions

CO 3: Distinguish between force and free convection mechanisms and calculate the heat transfer coefficient using dimensional analysis, empirical correlations and analogies

CO 4: Understand the phase change mechanism in boiling and condensation and determine the rate of heat transfer accompanying the phase change

CO 5:Calculate the area, no of tubes, heat duty of heat exchangers and evaporators

CO 6: Calculate radiation heat transfer between surfaces and understand view factor in radiation

Module 1 (13 hours)

Importance of heat transfer in chemical engineering operations, modes of heat transfer, Fourier's law of heat conduction, steady-state conduction through walls (single and multi-layers), heat flow through a cylinder and sphere, heat transfer in extended surfaces, unsteady state heat conduction.

Module 2 (14 hours)

Concepts of heat transfer by convection, individual heat transfer coefficient, calculation of overall heat transfer coefficients from individual coefficients, fouling factors, analogies between transfer of momentum and heat – Reynolds analogy, Prandtl and Colburn analogy, dimensional analysis in heat transfer, heat transfer coefficient for flow through pipe, non-circular conduit, flow past flat plate, flow through packed beds, heat transfer by natural convection, Heat transfer to fluids with phase change, heat transfer from condensing vapours, drop-wise and film type condensation, Nusselt equations for film type condensation, condensation for superheated vapours, heat transfer to boiling liquids, boiling of a saturated liquid, maximum flux and critical temperature drop, minimum flux and film boiling, sub-cooled boiling.

Module 3 (12 hours)

Evaporation: theory of evaporation, single effect and multiple effect evaporation, design calculation for single and multiple effect evaporators. Heat exchangers- counter-current and parallel flows, energy balances, overall heat transfer coefficient, log-mean temperature difference, heat transfer equipment, single pass and multi-pass heat exchangers, plate heat exchangers, design of heat exchangers. Radiation heat transfer- emissive power, blackbody radiation, emissivity, laws of radiation, radiation between surfaces.

Reference

1. McCabe, W.L. and Smith, J.C., Unit Operation of Chemical Engineering, 7th Edn., McGraw Hill, New York, 2014.
2. Holman, J.P., Heat Transfer, 10th Edn., McGraw Hill, 2017.
3. Kern, D.Q., Process Heat Transfer, McGraw Hill Co. Inc, 2001.
4. Coulson, J.M. and Richardson, J.F., Chemical Engineering, Vol 1, 6th Edn., Butterworth-Heinemann, 1999.
5. Cengel, Y. A, Ghajar, A. J, and Kanoglu, M., Heat and Mass Transfer Fundamentals and Applications, 5th Edn, McGraw Hill Education, 2017

CH2007D PROCESS INSTRUMENTATION

Pre-requisites: Nil

L	T	P	C
3	0	0	3

Total hours: 39

Course Outcomes:

CO1: Understand the principles involved in measurement systems.

CO2: Apply analytical and empirical approach to the measurement problems.

CO3: Acquire knowledge in the aspects of density, viscosity and pH measurement.

CO4: Select appropriate instruments for pressure, temperature, level and flow rate measurement.

CO5: Analyze measurement methods for composition of liquids and gases.

Module 1: (13 hours)

Characteristics of measurement system, classification, elements of measuring system and their functions, static and dynamic characteristics of instruments, calibration, Pressure measurement: manometers, elastic pressure transducers, electrical pressure transducers, vacuum measurement, differential pressure transmitters.

Module 2: (13 hours)

Temperature measurement: temperature scales, methods of temperature measurement, expansion thermometers, electrical temperature instruments, radiation and optical pyrometers, Flow measurement: area flow meters, mass flow meters, solid flow measurement, selection of flow meters.

Module 3: (13 hours)

Level measurement: float types, hydrostatic types and solid level measurement. Density, viscosity and pH measurement. Instruments for composition analysis: absorption spectroscopy, emission spectroscopy, mass spectroscopy and X-ray diffraction spectroscopy, chromatography methods, gas analysis by thermal conductivity.

References:

1. Eckman, D.P., Industrial Instrumentation, New York: Wiley Eastern Ltd., 1990.
2. Patranabis, Principles of industrial instrumentation, New York: Tata McGraw-Hill, 2008.
3. Jain, R.K., Mechanical and Industrial Measurements, Khanna Publishers, 2005.
4. Tattamangalam, R., Padmanabhan, Industrial Instrumentation: Principles and Design, Springer PublishingCompany, 2009.
5. Holman, J.P., Experimental Methods for Engineers, 7thed. New York: Tata McGraw-Hill, 2007.

CH2008D MATERIAL SCIENCE

Pre-requisites: NIL

L	T	P	C
3	0	0	3

Total hours: 39

Course Outcomes:

CO1: Write the importance of selection materials for engineering purposes

CO2: Describe the atomic structure and bonding in solids

CO3: Describe the phase diagrams of some important compounds

CO4: Understanding different failure mechanisms of materials

CO5: Describe the different properties of materials and their applications

Module 1 (11 hours)

Introduction to material science,Structure of atoms and molecules:bonding in solids, types of bonds and comparison of bonds,Fundamental structure of crystalline solids:Unit cells, crystalline systems, metallic crystal structures, ceramic crystal structures

Module 2 (13 hours)

Imperfections in solids: point defects, dislocations, interfacial defects,Phase diagrams-Binary phase diagrams, eutectic, eutectoid, peritectic, lever rule, microstructural changes during cooling,Mechanical Properties-Types of metal alloys, deformation, dislocation and plastic deformation,Failure of materials-fracture, fatigue, creep

Module 3 (15 hours)

Materials and their applications- Ceramic materials, Polymer materials, Composite Materials,Properties of Materials-Electrical properties, electronic properties, Magnetic properties, thermal properties, Processing of materials, Selection of materials

References

1. Callister, Materials Science and Engineering: An Introduction, 8th Edition, John Wiley and sons inc., Jan 2010
2. Shackelford, J.F and Pearson, Introduction to Materials Science for Engineers, 8^{th}edition.
3. Raghavan V., Material Science and Engineering Prentice Hall of India, 1996.
4. Van Vlack M., Materials Science for Engineers, Addison Welsey Publishing Company, 1980.
5. HajraChoudhary, S.K., Material Science and Processes, 2nd Edn., Indian Book Distributing Co., 1982.
6. Rose M. Shepard, John Wulff, The Structure and Properties of Materials, Vol.4 (Electronic properties), Wiley, 1984.
7. Adrianus J. Dekker, Electrical Engineering materials, Prentice Hall of India, 1992.
8. Anderson, J.C., Keith D. Leaver., Rees D. Rawlings., Patrick S,Leevers,Materials Science for Engineers, 5th Edition., Nelson Thornes Ltd., 2003

CH2092D FLUID MECHANICS LABORATORY

Pre-requisites: CH2003DFLUID MECHANICS LABORATORY

L	T	P	C
0	0	3	2

Lab Outcomes

Able to:

CO1: Make velocity measurements using flow meters

CO2: Conduct experiments and calculate the major and minor losses in fluid flow due to friction and pipe fittings

CO3: Demonstrate practical understanding of boundary layers, separation and drag.

CO4: Demonstrate and understand the fluid flow behavior in packed bed and fluidized bed systems.

CO5: Produce a working model through experience gained in fluid mechanics and explains its operation

List of experiments

11. Flow through orifice and mouthpiece
12. Discharge over notches
13. Verification of Bernoulli's principle
14. Laminar and turbulent flow in Reynolds apparatus
15. Discharge coefficient in Venturimeter and Orificemeter
16. Flow through packed bed column
17. Flow through fluidized bed column
18. Estimation of Drag coefficient
19. Losses due to pipe fittings, expansion and contraction
20. Losses due to friction in pipe line
21. Pitot tube apparatus
22. Characteristics test of centrifugal pump

References:

1. Cengel, Y.A. and John M. Cimbala, Fluid Mechanics – Fundamentals and Applications – 3rd Edition, McGraw-Hill, NY, 2013

CH2093D MECHANICAL OPERATIONS LABORATORY

Pre-requisites: Nil

L	T	P	C
0	0	3	2

Lab Outcomes:

CO 1: Understand the principles laws and mechanism of different comminuting methods

CO 2: Acquire knowledge of sieving and screen analysis

CO 3: Determine the crushing efficiency and reduction ratios of different size reduction equipment

CO 4: Evaluate settling characteristics of batch sedimentation process.

CO 5: Determine filtration area, cake and membrane resistance of leaf and plate and frame filtration unit.

List of experiments

1. Sieve analysis
2. Leaf filter
3. Plate and frame filter press
4. Sedimentation
5. Elutriation
6. Jaw crusher
7. Ball mill
8. Cyclone separator
9. Roll crusher
10. Hammer mill
11. Beaker decantation
12. Pipette analysis

Reference

1. McCabe, W.L. and Smith, J.C., Unit Operation of Chemical Engineering, 5th Edition., McGraw Hill, New York, 1993.

ME3104D PRINCIPLES OF MANAGEMENT

Pre-requisites: Nil

Total hours: 39

L	T	P	C
3	0	0	3

Course Outcomes:

CO1: Explain the characteristics and functions of managementin the contemporary context

CO2: Demonstrate ability in decision making process

CO3: Summarize the functional areas of management

CO4: Comprehend the concept of entrepreneurship and create business plans

Module 1 (15 hours)

Introduction to management, classical, neo-classical and modern management theories, Levels of managers and skill required. Management process – planning – mission – objectives – goals – strategy – policies – programmes – procedures. Organizing, principles of organizing, organization structures, Directing, leadership, motivation, Controlling.

Module 2 (11 hours)

Concept of productivity and its measurement; Competitiveness; Decision making process; decision making under certainty, risk and uncertainty; Decision trees; Models of decision making.

Module 3 (13 hours)

Introduction to functional areas of management, Operations management, Human resources management, Marketing management, Financial management, entrepreneurship, business plans, corporate social responsibility, patents and Intellectual property rights.

References

1. H. Koontz, and H. Weihrich, *Essentials of Management: An International Perspective.* 8th ed. McGraw-Hill, 2009.
2. R. W. Griffin, *Management: Principles and Applications,* Cengage Learning, 2008.
3. P. Kotler, K. L. Keller, A. Koshy, and M. Jha, *Marketing Management: A South Asian Perspective.* 14th ed. Pearson, 2012.
4. M. Y. Khan, and P. K. Jain, *Financial Management*, Tata-McGraw Hill, 2008.
5. R. D. Hisrich, and M. P. Peters, *Entrepreneurship: Strategy, Developing, and Managing a New Enterprise*, 4th ed. McGraw-Hill Education, 1997.
6. E. B. Roberts, *Entrepreneurs in High Tech-Lessons from MIT and beyond,* Oxford University Press, 1991
7. D. J. Sumanth, *Productivity Engineering and Management*, McGraw-Hill Education, 1985.

CH3001D CHEMICAL ENGINEERING THERMODYNAMICS II

Prerequisite: CH2005DCHEMICAL ENGINEERING THERMODYNAMICS II

Total hours: 39

L	T	P	C
3	0	0	3

Course outcomes:

CO1: Compute the thermodynamic properties of ideal and real gases and liquids, and their mixtures.

CO2: Identify and calculate phase equilibrium criteria.

CO3: Draw VLE diagrams under ideal and real systems.

CO4: Determine the equilibrium condition for homogenous and heterogeneous chemical reactions

Module 1 (13 hours)

Thermodynamic properties of ideal and real gases, departure functions and their calculations, multi component mixtures, partial molar properties, chemical potential, fugacity and fugacity coefficient and their estimation, thermodynamic properties of real gas mixtures, mixing rules, prediction of PVT properties and estimation of fugacity for real gas mixtures, fugacity of liquid and solid.

Module 2 (14 hours)

Properties of solutions, ideal solution, phase diagram and phase equilibrium, Margules equations, Wilson equations, Vapor-Liquid equilibrium – basic equation, reduction of VLE data, VLE at low to moderate pressures, azeotropic data, high pressure VLE, multi component vapor-liquid equilibria, bubble point and dew point calculations, VLE diagrams for ideal and azeotropic mixtures.

Module 3 (12 hours)

Chemical reaction equilibria – equilibrium constant, effect of temperature on equilibrium constant, homogeneous gas phase reactions, effect of operating conditions on degree of conversion at equilibrium, adiabatic reaction temperature, equilibrium with simultaneous reactions, homogeneous liquid phase reactions, heterogeneous reactions.

References:

1. Sandler, S. I., Chemical, Biochemical and Engineering Thermodynamics, 5thEdn.,Wiley Publications, 2017.
2. Elliot, J. R., and Lira, C. T., Introductory Chemical Engineering Thermodynamics, 2ndEdn., Prentice Hall, 2012.
3. Prausnitz, J. M., Lichtenthaler, R. N., and Azevedo, E. G., Molecular Thermodynamics of Fluid-Phase Equilibria, 3rdEdn, 1998.
4. Tester, J. W., and Modell, M., Thermodynamics and its Applications, 3rdEdn, Prentice Hall, 1997.
5. Van Ness, H. C.,Abbott, M. M., Swihart, M., and Smith, J. M., Introduction to Chemical Engineering Thermodynamics, 8thEdn, McGraw Hill Publications, 2017.
6. Noel De Nevers, Physical and Chemical Equilibrium for Chemical Engineers, 2ndEdn., Wiley, 2012.
7. YVC Rao, Chemical Engineering Thermodynamics, Universal Press India Pvt. Ltd, 2001

CH3002D MASS TRANSFER I

Prerequisite: Nil

L	T	P	C
3	0	0	3

Total hours: 39

Course outcomes:

CO1: Understand the principles of molecular diffusion and convective mass transfer

CO2: Determine diffusion coefficient, mass transfer coefficient and mass transfer rates derived from various theories and laws of mass transfer

CO3: Select appropriate contacting equipment for mass transfer operations

CO4: Design of absorption towers, dryers, humidifiers and crystallizer

Module 1: (14 hours)

Molecular diffusion in gases and liquids, steady state diffusion under stagnant and laminar flow conditions, diffusivity measurement and prediction, multi-component diffusion, molecular diffusion in solids and its applications, eddy diffusion, theories of mass transfer, analogy equations, mass transfer coefficients, interphase mass transfer, relationship between individual and overall mass transfer coefficients.

Module 2: (12 hours)

Steady state co-current, countercurrent and crosscurrent mass transfer processes, stages, cascade and stage efficiencies, stage wise and differential contactors, gas absorption – absorption factor, limiting gas-liquid ratio, tray tower absorber and calculation of no. of theoretical stages, packed tower absorbers – HETP, HTU, NTU calculations.

Module 3: (13 hours)

Humidification operations, humidity charts-Lewis relation, humidification and dehumidification equipment, theory and design of cooling towers, drying- theory and mechanism of drying, drying curves, classification of dryers, design of batch and continuous dryers, crystallization, theory, classification of crystallizers, design of continuous crystallizers.

References:

1. Treybal R.E, Mass Transfer Operations, 3rd Edn., McGraw Hill, 2017.
2. McCabe, W.L., Smith, J.C., and Harriot, P., Unit Operation of Chemical Engineering, 7th Edn., McGraw Hill, 2017.
3. Geankoplis, C. J., Hersel, A. A., and Lepk, D. H., “Transport Processes and SeparationProcess Principles”, 5th ed., Prentice Hall, 2018.
4. Sherwood T.K., Pigford R.L and White C.R, Mass Transfer, McGraw Hill, 1975.
5. Dutta, B. K., Principles of Mass Transfer and Separation Processes, PHI Learning, 2007.
6. Cussler, E. L., Diffusion Mass Transfer in Fluid Systems, 3rdEdn., Cambridge University Press, 2009.
7. Hines, A. L., and Maddox, R. N., Mass Transfer Fundamentals and Applications, 1stEdn, Pearson, 2016.
8. Wankat, C. P., Separation Process Engineering Includes Mass transfer Analysis, 4thEdn., Prentice Hall, 2017.
9. Seader, J. D., Henley E. J., and Roper D. K., Separation Process Principles with Applications using Process Simulators, 3rdEdn., Wiley, 2013.

CH3003D CHEMICAL REACTION ENGINEERING-I

Pre-requisites: Nil

Total hours: 39

L	T	P	C
3	0	0	3

Course Outcomes:

CO1: Describe different types of reactions and their mechanisms

CO2: Calculate the rate of homogeneous reactions and temperature dependency of reactions.

CO3: Design ideal flow reactors under isothermal and non-isothermal condition.

CO4: Analyze rate data from batch flow reactors

CO5: Select the appropriate reactors for the given duty

Module 1: (13 hours)

Introduction, kinetics of homogeneous reaction, Elementary and non-elementary reaction, search for a mechanism, temperature dependency from Arrhenius law, collision theory and transition state theory, analysis of batch reactor data, integral and differential method of rate analysis, method of initial rates and half-lives the rate law.

Module 2: (14 hours)

Isothermal reactors - Conversion and reactor sizing, general mole balance equation, Design equations for batch, mixed flow reactor and plug flow reactor. Multiple reactor systems in series and parallel recycle reactor and autocatalytic reactions, design for multiple reactions – series and parallel

Module 3: (12 hours)

Non-isothermal reactors- energy conservation equation, batch- stirred tank reactors, tubular-flow reactors, and continuous stirred tank reactors, stable operating conditions in stirred tank reactors, semi batch reactors, and optimum temperature profiles.

References:

1. Fogler H,S., Elements of Chemical Reaction Engineering, 5th Edition., Prentice Hall of India, 2016.
2. Levenspiel, O., Chemical Reaction Engineering, 3rdEdition., Wiley Eastern Limited, 1996.
3. Smith, J.M., Chemical Engineering Kinetics, McGraw Hill, 3rdEdition., 1981.
4. Froment, G.F. and Bischoff, K.B., Chemical Reactor Analysis and Design, John Wiley and Sons, 3rd edition, 2010.

CH3004D PROCESS DYNAMICS AND CONTROL

Pre-requisites:Nil

L	T	P	C
3	0	0	3

Total hours: 39

Course Outcomes:

CO1: Able to analyze the dynamics of processes

CO2: Derive the response of systems for various types input disturbances

CO3: Knowledge of feedback control with servo and regulatory action

CO4: Analyze open, closed loop responses and stability of systems

CO5: Design control systems of P/ PI /PID type and their tuning

Module 1: (12 hours)

General principles of process control, basic control elements, degree of freedom and fixing of control parameters, simple system analysis, Laplace transformation and transfer functions, block diagrams, linearization, effect of poles, zeros and time delays on system response, response of first order systems, transfer function, transient response, step response, impulse response, sinusoidal response, physical examples of first order systems, liquid level, mixing process, linearization, response of first order systems in series, non-interacting systems, interacting systems, higher order systems, second order and transportation lag, under damped systems, step response, impulse response, sinusoidal response

Module 2: (14 hours)

The control system, block diagram, servo problem and regulator problem, negative feed-back and positive feedback controllers and final control elements, ideal transfer functions, proportional, proportional integral and proportional integral derivative controllers, on-off controllers, supervisory control and data acquisition (SCADA),distributed control system (DCS), Stability, root locus, frequency response using Bode and Nyquist plots

Module 3: (13 hours)

control system design by frequency response, Bode stability criterion, gain and phase margins, Z-N controller settings, advanced control strategies, cascade control, feed forward control, ratio control, Smith predictor, internal model control, Control tuning and process identification, tuning rules (Ziegler-Nichol Rules and Cohen-Coon rules), process identification, step testing, semi-log plots for modeling control valves, control valve construction, valve sizing, valve characteristics, effective valve characteristics

References:

1. D.R. Coughanowr, S. E. LeBlanc, *Process System Analysis and Control*, 3rd Ed., McGraw Hill, 2017.
2. D.E. Seborg, T.F. Edgar and D.A. Mellichamp, *Process Dynamics and Control*, 2nd Ed., John Wiley and Sons, 2004.
3. B.W. Bequette, *Process Control: Modeling, Design and Simulation*, Prentice Hall, New Delhi, 2003.
4. W.L. Luyben, *Process Modeling Simulation and Control for Chemical Engineers*, 2nd Ed., McGraw Hill,1990.

CH3005D ENVIRONMENTAL STUDIES

Prerequisite: Nil

L	T	P	C
3	0	0	3

Total hours: 39

Course outcomes:

CO1: Understand the importance of an individual in conservation of environment.

CO2: Know about natural resources like forest, water and mineral and the problems associated with it.

CO3: Understand the concept of an ecosystem, ecological pyramids, food chains and food webs

CO4: Classify the types of pollution and understand their causes, effects and control measures.

CO5: Asses and report a real time problem in the environment and a solution for it.

Module 1: (13 hours)

Multidisciplinary nature of environmental studies, definition, scope and importance, need for public awareness, natural resources, renewable and non-renewable resources, natural resources and associated problems, forest resources, use and over-exploitation, deforestation, case studies. timber extraction, mining, dams and their effects on forest and tribal people, water resources, use and over-utilization of surface and ground water, floods, drought, conflicts over water, dams-benefits and problems, mineral resources, use and exploitation, environmental effects of extracting and using mineral resources, case studies, food resources, world food problems, changes caused by agriculture and over-grazing, effects of modern agriculture, fertilizer-pesticide problems, water logging, salinity, case studies, energy resources, growing energy needs, renewable and non-renewable energy sources, use of alternate energy sources, case studies, land resources, land as a resource, land degradation, man induced landslides, soil erosion and desertification, role of an individual in conservation of natural resources, equitable use of resources for sustainable lifestyles.

Module 2: (13 hours)

Ecosystems, concept of an ecosystem, structure and function of an ecosystem, producers, consumers and decomposers, energy flow in the ecosystem, ecological succession, food chains, food webs and ecological pyramids, introduction, types, characteristic features, structure and function of the following ecosystems, forest ecosystem, grassland ecosystem, desert ecosystem, aquatic ecosystems (ponds, streams, lakes, rivers, oceans, estuaries), biodiversity and its conservation – introduction, definition, genetic, species and ecosystem diversity, bio geographical classification of India, value of biodiversity, consumptive use, productive use, social, ethical, aesthetic and option values, biodiversity at global, national and local levels, India as a mega-diversity nation, hotspots of biodiversity, threats to biodiversity, habitat loss, poaching of wildlife, man-wildlife conflicts, endangered and endemic species of India, conservation of biodiversity-in-situ and ex-situ conservation of biodiversity.

Module 3: (13 hours)

Environmental pollution – definition, cause, effects and control measures of, air pollution, water pollution, soil pollution, marine pollution, noise pollution, thermal pollution, nuclear hazards, solid waste management, causes, effects and control measures of urban and industrial wastes, role of an individual in prevention of pollution, pollution case studies, disaster management, floods, earthquake, cyclone and landslides, Social issues and the environment, from unsustainable to sustainable development-urban problems related to energy, water conservation, rainwater harvesting, watershed management, resettlement and rehabilitation of people, its problems and concerns. Case studies, environmental ethics, issues and possible solutions- climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust, case studies. Wasteland reclamation, consumerism and waste products, Environment Protection Act, Air (Prevention and Control of Pollution) Act, Water (Prevention and control of Pollution) Act, Wildlife Protection Act, Forest Conservation Act. Issues involved in enforcement of environmental legislation- public awareness. Human population and the environment, population growth, variation among nations, population explosion – Family Welfare Programme, environment and human health, human rights, value education, HIV/AIDS, women and child welfare, role of information technology in environment and human health, case studies.

Field work:

- Visit to a local area to document environmental assets-river/forest/grassland/hill/mountain
- Visit to a local polluted site-urban/rural/industrial/agricultural
- Study of common plants- insects, birds.
- Study of simple ecosystems-pond- river, hill slopes, etc.

(Field work Equal to 5 lecture hours)

References:

1. Clark R.S., Marine Pollution, Clanderson Press, Oxford
2. Mhaskar A.K., Matter Hazardous, Techno-Science Publication.
3. Miller T.G. Jr., Environmental Science, Wadsworth Publishing Co.
4. Trivedi R. K. and P.K. Goel, Introduction to air pollution, Techno-Science Publication
5. Agarwal, K.C, Environmental Biology, Nidi Publ. Ltd. Bikaner, 2001
6. BharuchaErach, The Biodiversity of India, Mapin Publishing Pvt. Ltd., Ahmedabad –380 013, India
7. Brunner R.C., Hazardous Waste Incineration, McGraw Hill Inc. 1989
8. Cunningham, W.P. Cooper, T.H. Gorhani, E & Hepworth, M.T., Environmental Encyclopedia, Jaico Publ. House, Mumbai, 2001
9. De A.K., Environmental Chemistry, Wiley Eastern Ltd.
10. Down to Earth, Centre for Science and Environment
11. Gleick, H.P., Water in Crisis, Pacific Institute for Studies in Development, Environment & Security, Stockholm Environmental Institute Oxford University Press, 1993.
12. Hawkins R.E., Encyclopedia of Indian Natural History, Bombay Natural History Society, Bombay
13. Heywood, V.H &Waston, R.T., Global Biodiversity Assessment, Cambridge University Press, 1995.
14. Jadhav, H &Bhosale, V.M., Environmental Protection and Laws. Himalaya Pub. House, Delhi, 1995.
15. Mckinney, M.L. & School, R.M., Environmental Science Systems & Solutions, Web enhanced edition, 1996.
16. Odum, E.P., Fundamentals of Ecology, W.B. Saunders Co. USA, 1971.
17. Rao M N. &Datta, A.K, Waste Water treatment. Oxford & IBH Publ. Co. Pvt. Ltd., 1987
18. Sharma B.K., Environmental Chemistry, Goel Publ. House, Meerut, 2001.
19. Survey of the Environment, The Hindu (M)
20. Townsend C., Harper J, and Michael Begon, Essentials of Ecology, Blackwell Science
21. Trivedi R.K., Handbook of Environmental Laws, Rules Guidelines, Compliances and Standards, Vol I and II, Enviro Media.
22. Wanger K.D., Environmental Management, W.B. Saunders Co., Philadelphia, USA,1998 (M)Magazine

CH3091D HEAT TRANSFER LABORATORY

Prerequisite: CH2006DHEAT TRANSFER LABORATORY

L	T	P	C
0	0	3	2

Course outcomes:

CO1: Design and conduct experiments on process heat transfer equipment to achieve desired outcomes.

CO2:Collect and analyze experimental data using statistical principles, and compare results to theoretical principles.

CO3: Identify safety concerns related to the experimental processes.

CO4: Write effective reports.

CO5: Work as a member of a team.

List of experiments:

1. Heat conduction
2. Natural convection
3.Forced convection
4. Thermal radiation-determination of emissivity
5. Double pipe heat exchanger
6. Shell and tube heat exchanger
7. Fin tube heat exchanger
8. Plate Heat exchanger
9. Heat transfer in agitated vessels
10. Open pan evaporator
11. Heat pipe demonstrator
12. Fluidized bed heat transfer

References:

1. Cengel, Y. A, Ghajar, A. J, and Kanoglu, M., Heat and Mass Transfer Fundamentals and Applications, 5 thEdn, McGraw Hill Education, 2017.

2. Holman, J. P., Experimental Methods for Engineers, 8 thEdn., McGraw Hill Education, 2011.

MS3001D ENGINEERING ECONOMICS

Pre-requisites: Nil

L	T	P	C
3	0	0	3

Total Hours: 39

Course Outcomes:

CO1:To evaluate the economics of the management, operation, and growth and profitability of engineering firms and analyze operations of markets under varying competitive conditions

CO2: The course equips a student to carry out and evaluate benefit/cost, life cycle and breakeven analyses on one or more economic alternatives

CO3:To analyze cost/revenue data and carry out make economic analyses in the decision making process to justify or reject alternatives/projects on an economic basis.

CO4: Produce a constructive assessment of a social problem by drawing the importance of environmental responsibility and demonstrate knowledge of global factors influencing business and ethical issues.

CO5: Helps to use models to describe economic phenomena; analyze and make predictions about the impact of government intervention and changing market conditions on consumer and producer behavior and well-being.

Module 1: (9 hours)

General Foundations of Economics; Forms of organizations-Objectives of firms-Opportunity principle-Discounting, Marginalism versus Incrementalism-Production Possibility frontier-Central problems of an economy- Two sector, Three sector and Four sector circular flow of income. Demand analysis-Individual, Market and Firm demand, Determinants of demand and supply, Shifts and changes in demand and supply, Market equilibrium, Shortages versus surpluses, Price ceiling ,Price floor- Elasticity of demand and business decision making.

Module 2: (16 hours)

Production functions in the short and long run-Cost concepts- Short run and long run costs- economies and diseconomies of scale-economies and diseconomies of scope-Break even analysis-Vertical & horizontal integration-Product markets- Market structure-Competitive market-Imperfect competition (Monopoly, Monopolistic competition and Oligopoly); Price discrimination Inflation and deflation ; Fiscal and Monetary Policies ; Monetary system; Indian stock market; Development Banks; NBFIs, role of Reserve Bank of India, Money Market, Capital market; NIFTY, SENSEX

Module 3: (14 hours)

Game Theory-Prisoner's Dilemma-Maximin, Minimax, Saddle point, Nash Equilibrium, Break even analysis; Margin of safety, Time value of money, Discounting and compounding, interest rates, Depreciation, Replacement and Maintenance analysis – Types of maintenance, types of replacement problem, determination of economic life of an asset, Replacement of an asset with a new asset, Capital Budgeting.

References:

1. R. S. Pindyck, D. L. Rubinfield and P. L. Mehta, *Microeconomics*, Pearson Education, 9th Edition, 2018.
2. P. A. Samuelson and W. D. Nordhaus,*Economics*, Tata McGraw Hill, 19th ed., 2015.

3. N. G. Mankiw, *Principles of Microeconomics*, Cengage Publications, 7th ed., 2014.
4. S. B. Gupta, *Monetary Economics: Institutions, Theory & Policy*, New Delhi: S. Chand & Company Ltd., 2013.
5. K. E. Case, R. C. Fair and S. Oster, *Principles of Economics*, Prentice Hall, 10th ed., 2011.
6. C.S.Park, *Fundamentals of Engineering Economics,* Prentice Hall, 3rd ed., 2012.

Note: Supplementary materials would be suggested / supplied for select topics on financial markets and Indian economy.

CH3006D MASS TRANSFER II

Prerequisite: CH3002DMASS TRANSFER II

L	T	P	C
3	0	0	3

Total hours: 39

Course outcomes:

CO1: Understand the basic principles of two-phase mass transfer operations

CO2: Apply thermodynamic equilibrium data to describe the separation processes

CO3:Construct principles of operating line and equilibrium description to analyze separation process principles

CO4: Design of distillation, extractors and adsorption column

Module 1: (13 hours)

Distillation, methods of distillation, batch, continuous, flash distillation, differential distillation, steam distillation, continuous fractionation – stage wise and continuous contact operations, method of McCabe and Thiele, method of Ponchon-Savarit, reboilers and condensers, multicomponent distillation,azeotropic distillation and extractive distillation.

Module 2: (12 hours)

Liquid extraction, single stage extraction, counter-current multistage extraction.stage efficiency, extraction equipment, leaching, equipment for leaching operation, multistage continuous cross current and counter current leaching.

Module 3: (14 hours)

Adsorption – types, nature of adsorbents, effect of pressure and temperature on adsorption isotherms, adsorption operations – stage wise operations, steady state moving bed and unsteady state fixed bed adsorbers, break through curves, novel separation processes, membrane separation- reverse osmosis, dialysis, ion exchange, techniques and applications.

References:

1. Treybal R.E, Mass Transfer Operations, 3rd Edn., McGraw Hill, 2017.
2. McCabe, W.L., Smith, J.C., and Harriot, P., Unit Operation of Chemical Engineering, 7th Edn., McGraw Hill, 2017.
3. Geankoplis, C. J., Hersel, A. A., and Lepk, D. H., “Transport Processes and SeparationProcess Principles”, 5th ed., Prentice Hall, 2018.
4. Dutta, B. K., Principles of Mass Transfer and Separation Processes, PHI Learning, 2007.
5. Hines, A. L., and Maddox, R. N., Mass Transfer Fundamentals and Applications, 1stEdn, Pearson, 2016.
6. Wankat, C. P., Separation Process Engineering Includes Mass transfer Analysis, 4thEdn., Prentice Hall, 2017.
7. Seader, J. D., Henley E. J., and Roper D. K., Separation Process Principles with Applications using Process Simulators, 3rdEdn., Wiley, 2013.
8. King, C. J., Separation Processes, 2ndEdn, Dover Publications, 2013.

CH3007D CHEMICAL PROCESS EQUIPMENT DESIGN

Prerequisite: CH2006D, CH3002DCHEMICAL PROCESS EQUIPMENT DESIGN

L	T	P	C
4	0	0	4

Total hours: 52

Course outcomes:

CO1: Integrate the knowledge acquired in different chemical engineering courses in the design of a chemical plant.

CO2: Comply with environmental regulations in the design of the plant, especially separation columns

CO3: Choose and design appropriate process equipment for required applications

CO4: Evaluate the performance of the process equipment and conduct the feasibility study

Module 1: (16 hours)

Design of fluid transport equipment, design of piping networks, design of pressure vessels-tall vessels, design of skirt supports, lug supports and saddle supports for vessels.

Module 2: (18 hours)

Process and mechanical design of heat exchanging equipment- heat exchangers, evaporators and driers.

Module 3: (18 hours)

Process and mechanical design of tray and packed distillation and absorption columns.

References:

1. Mahajan, V.V. and Umarji, S. B.,Process Equipment Design, 4thEdn., Macmillan & Co. India, 2009.
2. Indian Standard Specifications IS-803, 1962; IS-4072, IS-2825, 1969. Indian StandardInstitution, New Delhi, 1967.
3. Perry, R.H.and Green, D.W., Chemical Engineers Handbook, 8th Edn., McGraw Hill, 2007.
3. Towler, G., and Sinnott, R., Chemical Engineering Design: Principles, Practice and Economics of Plant and Process Design, 2ndEdn., Butterworth-Heinemann, 2012.
4. Couper, J. R., Penny, W. R., Fair, J. R., and Walas, S. M., Chemical Process Equipment Selection and Design, 3rdEdn., Butterworth-Heinemann, 2012.

CH3008D CHEMICAL REACTION ENGINEERING-II

Pre-requisites: CH3003DCHEMICAL REACTION ENGINEERING-II

L	T	P	C
3	0	0	3

Total hours: 39

Course Outcomes:

CO1: Calculate the RTD of the fluid using tracer analysis and predict the conversion for real reactors.

CO2: Describe and understand heterogeneous chemical reactions

CO3: Calculate the rate of real reactors and reactions

Module 1: (13 hours)

Non-ideal reactors **-** Deviation from ideal reactor performance- RTD – C, E, F Curve, measurement of RTD, RTD in ideal real reactors. Models of non-ideal flow – Tanks in series model, Dispersion model and segregated model.

Module 2: (14 hours)

Heterogeneous processes- global rates of reaction, types of heterogeneous reactions, catalysis- the nature and mechanism of catalytic reactions, adsorption- surface chemistry, isotherms and rate of adsorption, solid catalysis- determination of surface area, void volume and solid density, pore- volume distribution, theories of heterogeneous catalysis, classification of catalysts, catalyst preparation, promoters and inhibitors, catalyst deactivation.

Module 3: (12 hours)

Rate equations for fluid-solid catalytic reactions- rates of adsorption, desorption, surface reactions, rate equation in terms of fluid phase concentrations at the catalytic surface, qualitative analysis of rate equations, quantitative interpretation of kinetic data, redox rate equations, kinetics of catalyst deactivation, external transport processes in Fixed bed reactors- the effect of physical processes in observed rate of reaction, mass and heat transfer coefficients in packed beds, quantitative treatment of external transport effects, stable operating conditions, effect of external transport process on selectivity. Fluidized bed reactors- particle- fluid mass and heat transfer, Slurry reactors- Mass transfer coefficients, effect of mass transfer on observed rates, Tricked bed reactors- Mass transfer coefficients, calculation of global rate.

References:

1. Fogler H,S., Elements of Chemical Reaction Engineering, 5th Edition., Prentice Hall of India, 2016.
2. Levenspiel, O., Chemical Reaction Engineering, 3rdEdition., Wiley Eastern Limited, 1996.
3. Smith, J.M., Chemical Engineering Kinetics, McGraw Hill, 3rdEdition., 1981.
4. Froment, G.F. and Bischoff, K.B., Chemical Reactor Analysis and Design, John Wiley and Sons, 3rd edition, 2010.

CH3092D PROCESS DYNAMICS AND CONTROL LABORATORY

Prerequisite: CH3004DPROCESS DYNAMICS AND CONTROL LABORATORY

L	T	P	C
0	0	3	2

Course outcomes:

CO1: Determine the dynamic response of first order and second order type systems to different forcing functions.

CO2: Determine and compare the response of different types of controllers.

CO3: Do the tuning of different types of controllers for a stable response.

CO4: Apply advance control strategies like cascade control systems.

CO5:Use simulation tools for process control systems for computer control of chemical engineering processes

List of experiments:

1. Calibration of thermocouple and thermometer.
2. Cascade control trainer.
3. Programmable logic controller.
   a) Step response of first order system.
   b) Step response of a second order system.
4. Level Control trainer.
5. Control valve characteristics.
6. Simulation of pressure control loop.
   a) Step response of first order non-interacting system.
   b) Step response of first order interacting system.

References:

1. D.R. Coughanowr, S. E. LeBlanc, *Process System Analysis and Control*, 3rd Ed., McGraw Hill, 2017

CH4001D TRANSPORT PHENOMENA

Pre-requisites: CH3003D, CH3006DTRANSPORT PHENOMENA

L	T	P	C
3	0	0	3

Total hours: 39

Course Outcomes:

CO1:Understand the mechanisms of momentum, heat and mass transport at molecular, micro and macro levels.

CO2: Derive expressions for velocity profiles, average velocity and momentum flux at the surface using shell momentum balance and equations of change for isothermal systems.

CO3: Derive expressions for temperature profiles, average temperature and heat flux at the surface using shell energy balance and equations of change for non-isothermal systems.

CO4: Derive expressions for concentration profiles, average concentration and mass flux at the surface using shell mass balance and equations of change for multicomponent systems.

Module 1: (13 hours)

General overview of momentum, heat and mass transport mechanism, level of transport, driving forces, vector and tensor notation, shell momentum balance – velocity profile; average velocity and momentum flux at the surface,equations of change for isothermal systems– equation of continuity; equation of motion and Navier-Stokes equation, dimensional analysis of equations of change for isothermal systems.

Module 2: (13 hours)

Thermal conductivity and mechanism of energy transport, shell energy balance - temperature profile; average temperature and heat flux at the surface,equations of change for non-isothermal systems – equation of continuity; equation of motion and equation of energy, dimensional analysis of equations of change for non-isothermal systems.

Module 3: (13 hours)

Diffusivity and mechanism of mass transport, shell mass balance – concentration profile; average concentration and mass flux at the surface, equations of change for multi-component systems – equation of continuity for multi-component systems; equation of motion and equation of energy, dimensional analysis of equations of change for non-reacting binary mixtures.

References:

1. R.B. Bird, W.E. Stewart, and E.W. Lightfoot, *Transport Phenomena*. 2nd ed. New York: John Wiley & Sons, Inc., 2002.
2. R.S. Brodkey,and H.C. Hershey, *Transport Phenomena*. New York: McGraw Hill., 1988.
3. J.R. Wilty, R.W. Wilson, and C.W. Wicks, *Fundamentals of Momentum, Heat and Mass Transfer.* New York: JohnWiley& Sons. 1984.
4. C.J. Geankoplis,*Transport Processes and Separation Processes Principles.* 4th ed. New Jersey: Pearson Education Inc., 2003.

CH4002D COMPUTER APPLICATIONS IN CHEMICAL ENGINEERING

Pre-requisites: Nil

Total hours: 39

L	T	P	C
2	0	2	3

Course Outcomes:

CO1: List, Identify and differentiate traditional computational methods in chemical engineering

CO2: Develop skills to solve chemical engineering problems by traditional methods

CO3: Illustrate artificial intelligence (AI) methodologies and learning rules

CO4: Develop working knowledge of Artificial Neural Networks and their applications in chemical engineering

CO5: Develop MATLAB programming skills to solve traditional and non-traditional computational methods

Module 1: (16 hours)

Introduction to process modeling and simulation, limitations and usefulness of process modeling and simulation, model building steps, classification of process models- steady and unsteady state models; lumped parameter versus distributed parameter models; continuous versus discrete models; linear versus non-linear models; deterministic versus stochastic models; mechanistic versus empirical models, development of models for various chemical engineering process units, computational methods for the solution of process models, simulation of the process models using MATLAB and interpretation of results, introduction to process engineering packages (Aspen Plus, Aspen Hysys).

Module 2: (12 hours)

Introduction to knowledge based applications, applications of artificial intelligence (AI) in chemical engineering, AI principles, introduction to AI programming, introduction to prolog and programming in prolog, expert system design and development- expert system for separation process synthesis, applications in various chemical processes.

Module 3: (11 hours)

Introduction to artificial neural networks (ANNs), fundamentals of ANNs, setting of weights, activation function, bias, threshold, learning rules, perceptron networks, feedforward networks, back propagation strategy, training algorithms, application of ANNs in chemical engineering- process modeling; process control; fault diagnosis and process forecasting, ANN MATLAB toolbox, limitations of ANNs, problem solving using MATLAB neural network toolbox.

References:

1. W. L. Luyben, *Process Modeling, Simulation and Control for Chemical Engineers*, 2nd ed., New York: McGraw-Hill Publisbing Company, 1999.
2. S.C. Chapra and R.P. Canale, *Numerical Methods for Engineers*, 7th ed., New York: McGraw-Hill Education, 2015.
3. T.E Quantrille and YA Liu, *Artificial Intelligence in Chemical Engineering*, Sand Diego: Academic Press, 1991.
4. Angelo Basile, Stefano Curcio, Artificial Neural Networks in Chemical Engineering, Nova Science Publishers, 2017.

CH4003DPROCESS OPTIMIZATION

Pre-requisites: Nil

Total hours: 39

L	T	P	C
3	0	0	3

Course Outcomes:

CO1: Summarize the concepts and formulation of optimization problems

CO2: Develop knowledge to solve unconstrained single and multi-variable optimization problems

CO3: Develop knowledge to solve linear and non-linear constrained optimization problems

CO4: Apply developed skills to optimize chemical engineering process

Module 1: (12 hours)

Scope and hierarchy of optimization, applications of optimization in chemical engineering, essential features of optimization problems, formulation of the objective function, basic concepts of optimization, optimality criteria, unimodal functions, convexity and its applications.

Module 2: (13 hours)

Unconstrained single variable optimization: Numerical methods for optimizing a single function- scanning and bracketing procedures; Newton and Quasi-Newton methods of unidimensional search; polynomial approximation methods; one-dimensional search applied in a multi-dimensional problem, unconstrained multi-variable optimization - methods that use function values; methods that use first derivatives- Newton's method, Quasi-Newton's method

Module 3: (14 hours)

Linear programming: Formulation of Linear Programming Problem (LPP), solution of LPP by graphical and simplex method, Barrier methods and revised simplex method, sensitivity analysis, Linear Mixed Integer Programs, Linear Programming software, Non-linear programming with constraints- direct substitution; quadratic programming; penalty, Barrier and Lagrangian methods; successive linear programming; successive quadratic programming; generalized reduced gradient method, dynamic programming.

References:

1. T.F. Edgar and D.M. Himmelblau, *Optimization of Chemical Processes*, 2nd ed., New York: McGraw-Hill, 2001.
2. A. Ravindran, K.M. Ragsdell, and G.V. Reklaitis, *Engineering Optimization*, 2nd ed., New Jersey: John Wiley & Sons, 2006.
3. R. Smith, *Chemical Process Design and Integration*, New Jersey: John Wiley & Sons Ltd, 2005.
4. G. G. Luenberger and Y. Ye, *Linear and Nonlinear Programming*, 3rd ed., New York: Springer, 2008.
5. S.S. Rao, *Engineering optimization – Theory and Practice*, 4th ed., New Jersey: John Wiley & Sons, 2009.

CH4091D MASS TRANSFER LABORATORY

Pre-requisites: CH3006DMASS TRANSFER LABORATORY

L	T	P	C
0	0	3	2

Lab Outcomes

CO1: Design and conduct experiments on mass transport and separation equipment's to achieve desired outcomes.

CO2: Collect and analyze experimental data using statistical principles, and compare results to theoretical principles.

CO3: Identify safety concerns related to the experimental processes.

CO4: Write effective reports.

CO5: Work as a member of a team.

List of experiments:

1. Distillation
2. Diffusivity coefficient determination
3. Mutual solubility data
4. Extraction
5. Batch drying
6. Mass transfer in packed tower
7. Mass transfer in spray tower
8. Ion-exchange apparatus
9. V.L.E data
10. Adsorption
11. Absorption studies in packed bed
12. Batch crystallizer
13. Cooling tower
14. Leaching

References:

1. Treybal R.E, Mass Transfer Operations, 3rd Edn., McGraw Hill, 2017.

CH4092D CHEMICAL REACTION ENGINEERING LABORATORY

Pre-requisites: CH3008DCHEMICAL REACTION ENGINEERING LABORATORY

L	T	P	C
0	0	3	2

Lab Outcomes

Able to:

CO1: Estimate the kinetic parameters of an ideal reactor.

CO2: Calculate the rate constant and activation energy of a reaction

CO3: Understand and calculate the RTD in Non-ideal reactors

List of experiments:

1. Plug flow reactor
2. Continuous stirred tank reactor
3. Combined Flow Reactor.
4. Isothermal semi batch reactor.
5. Adiabatic batch reactor
6. Isothermal Batch reactor
7. Packed Bed Reactor
8. Kinetics of a reaction
9. Hydrolysis of a reaction

References:

1. Levenspiel, O., Chemical Reaction Engineering, 3rd Edition., Wiley Eastern Limited, 1996.

CH4093D PROJECT: PART 1

Pre-requisites: Nil

L	T	P	C
0	0	4	2

Course outcomes:

CO1: Work in a team and select a problem for project work

CO2: Review and evaluate the available literature on the chosen problem

CO3: Formulate the methodology to solve the identified problem

CO4: Apply the principles, tools and techniques to solve the problem

CO5:Acquire written and oral presentation skills

The project work will be based on design, experiment or computation, on any topic related to Chemical Engineering. The work should be done as a group consisting of three to four students. The assessment of the project will be done twice during a semester: mid-way through the semester and at the end of the semester, by a committee consisting of three to four faculty members. The students will present their project work before the committee. The complete project report is not expected at the end this semester. However, a three or four page typed report based on the work done should be submitted by the students to the assessing committee. The project guides will award the grades to the individual students depending on the group average marks awarded by the committee.

. CH4095D PROJECT: PART 2

L	T	P	C
0	0	12	6

Pre-requisites: CH4093DPROJECT

Course outcomes:

CO1: Work in a team and select a problem for project work

CO2: Review and evaluate the available literature on the chosen problem

CO3: Formulate the methodology to solve the identified problem

CO4: Apply the principles, tools and techniques to solve the problem

CO5: They will get the concept of technical and thesis writing

The project work started in the seventh semester is to be continued in this semester. The students should complete the project work by the end of this semester and present it before the assessment committee. The assessment committee as constituted in the seventh semester will assess the various projects. The guides will award the grades for the individual students depending on the group average marks. Each group will submit the copies of the completed project report signed by the guide to the department. The Head of the Department will certify the copies and return them to the students. One copy will be kept in the departmental library.

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CH4094D SEMINAR

Pre-requisites: Nil

L	T	P	C
0	0	3	1

Course outcomes:

CO 1: Able to understand the recent trends and challenges in the field of Chemical engineering

CO 2: Acquire knowledge in the specialised areas of Chemical engineering

CO 3: Improve communication skills, presentation skills and other soft skills.

CO4: Prepare and present a technical report

Each student will be assigned a topic of interest in Chemical Engineering. A report is to be submitted to the coordinator previous to presenting the topic. The presentation will be for duration of approximately thirty minutes, which will be followed by discussion. The topic is to be selected from outside the purview of prescribed textbooks preferably from peer reviewed journals.

CH3021D ENERGY TECHNOLOGY

Prerequisite: Nil

L	T	P	C
3	0	0	3

Total hours: 39

Course outcomes:

CO 1: Understand the present and future energy challenges in our society.

CO 2: Knowledge of the principles and technologies involved in harnessing energy from various renewable energy sources.

CO 3: Perform energy audits in process plants and to do process integration of various unit operations.

CO 4: Compare the efficiencies of various conventional power plants.

CO 5: Classify the energy storage and conversion devices.

Module 1: (15 hours)

General classification of energy, world and Indian energy resources and energy consumption, energy crisis, energy alternatives, electrical energy from conventional energy resources - thermal, hydel and nuclear power plants,efficiency, merits and demerits of the above power plants, fluidized bed combustion, Energy conservation in chemical process plants, energy audit, pinch technology, process integration.

Module 2: (12 hours)

Solar energy – solar thermal systems, flat plate collectors, focusing collectors, solar water heating, solar cooling,solar distillation, solar refrigeration, solar dryers, solar pond, solar thermal power generation, solar energyapplication in India, energy plantations, wind energy – types of windmills, types of wind rotors – Darrieus rotor andGravian rotor, wind electric power generation, wind power in India, economics of wind farm, ocean wave energy conversion, ocean thermal energy conversion, tidal energy conversion, geothermal energy.

Module 3: (12 hours)

Biomass energy resources, thermochemical and biochemical methods of biomass conversion – combustion,gasification, pyrolysis, biogas production, ethanol, fuel cells – alkaline fuel cell, phosphoric acid fuel cell, moltencarbonate fuel cell, solid oxide fuel cell, solid polymer electrolyte fuel cell, magneto hydrodynamic powergeneration, energy storage routes like thermal, chemical, mechanical and electrical storage.

References:

1. El. Wakil, Power Plant Technology, New York,Tata McGraw Hill, 1999
2. A.K. Raja, A.P. Srivastava, M. Dwivedi, Power plant engineering, New age International (P) limited publishers, 2006
3. John Twidell, Tony Weir, Renewable Energy Resources, Taylor & Francis, 2005
4. Jean Claude Sabonnadi, Renewable Energy Technologies, Wiley-ISTE, 2009
5. Robin Smith, Chemical Process Design and Integration, John Wiley & Sons, 2005
6. W. F. Kenney, Energy Conservation in the Process Industries, Academic Press Inc., 1984
7. YasarDemirel, Energy production, Conversion, Storage, Conservation, and Coupling, Springer, Verlag London, 2012
8. Aldo V. da Rosa, Fundamentals of Renewable Energy Processes, Elsevier Academic Press, 2005

CH3022D PETROLEUM REFINING OPERATIONS AND PROCESSES

Pre-requisites: Nil

Total hours: 39

L	T	P	C
3	0	0	3

Course Outcomes:

CO 1: Have a knowledge on the past, present and future of petroleum industry nationally and globally, study the nature of crude oil components and various characterization methods for crude evaluation.

CO2: Acquire knowledge of process involved in converting crude oil to various products such as reforming, alkylation, isomerization, HDS.

CO3: Understand the process technology involved in production and storage of LPG and LNG from its raw material. Know the principles and technologies involved in Fluid catalytic cracking, hydro desulphurization andother processes in cracking of crude oil and gas.

CO4: Understanding of various reaction mechanism and steps of refinery operations.

CO5: Provide an overview on the manufacture of petrochemicals

Module 1: (13 hours)

Indian petroleum industry, prospects and future, composition of crude and classification of crude oil, evaluationof crude oil and testing of petroleum products, refining of petroleum, atmospheric and vacuum distillation,thermalcracking, visbreaking, coking, catalytic cracking (FCC), hydrocracking, air blowing of bitumen. Treatment techniques for removal of sulfur compounds to improve performance.

Module 2: (13 hours)

Production and treatment of LPG, LNG technology, sweetening operations for gases including merox, ethanolamine, copper chloride, etc., storage and stability, product treatment processes: various solvent treatment processes, dewaxing, clay treatment and hydrofining. Catalytic reforming of petroleum feed stocks, extraction of aromatics, hydrogen addition processes, hydrovisbreaking(hycar) process, solvent processes, deasphalting process, demax process.

Module 3: (13 hours)

Isomerization, alkylation and polymerization, process types, chemistry, commercial processes, catalysts, cracking of naphtha and gasfor the production of ethylene, propylene isobutylene and butadiene, production of acetylene from methane, production of petrochemicals like, ethylene glycol, acrylonitrile, phthalic anhydride, maleic anhydride, phenol, acetone, methanol, formaldehyde, acetaldehyde and, production of carbon black.

References:

5. B.K.B Rao, Modern Petroleum Refining Processes, 5thed, New Delhi, India, Oxford and IBH

Publishing Company, 2008.
6. M. G. Rao and M. Sitting, 3rded, New Delhi, India, Affiliated East-West Press Pvt Ltd, 1997.
7. W.L. Nelson, Petroleum Refinery Engineering, 4th ed, New York, McGraw Hill,1995.
8. B.K.B.Rao, A Text on Petrochemicals, 5thed, New Delhi, India, Khanna Publishers,2015.
9. C.S. Hsu and P.R. Robinson,Practical Advances in Petroleum Processing: Volume 1 & 2, Springer Publications, 2006.
10. G.N. Sarkar, Advanced Petroleum Refining, Khanna Publishers, 2008.
11. R.E. Maples, Petroleum Refinery Process Economics, PennWell Corporation, 2000.
12. R. Prasad, Petroleum Refining Technology, Khanna Publishers, 2010.

CH3023D CORROSION ENGINEERING

Pre-requisites: Nil

L	T	P	C
3	0	0	3

Total hours: 39

Course Outcomes:

CO 1: Understanding the basic concepts on different types of corrosion due to the impact of environmental pollution and able to determine the rate of corrosion on solid surfaces

CO2: Understand the use of electrochemical different types of polarization and evaluate Gibbs free energy.

CO3:Understand the use of Tafel plots and evaluate passivation studies on anodic protection method.

CO4:Understand and explain the common methods of corrosion control: materials selection and design, coatings, inhibitors, galvanic and electrochemical protection.

CO5: Locate and utilize electrochemical data to postulate and formulate electrochemical half-cell and cell reactions for corrosion processes.

CO6: Understand and explain the use of electrochemical tests in corrosion testing: cathodic and anodic polarization experiments.

CO 7: Understand and explain the role of passivity in the corrosion resistance of materials such as stainless steel.

Module 1 (13 hours)

Introduction: Definition of corrosion, environment, corrosion damage, appearance, maintenance and operating costs, plant shut downs, contamination of product, loss of valuable products, effects on safety and reliability, classification of corrosion principle – introduction, rate expression, electrochemical reaction, polarization passivity, environmental affect, effect of oxygen and oxidizers, velocity, temperature, corrosive concentration, effect of galvanic coupling, metallurgical aspects, metallic properties, ringworm corrosion. Modern theory – principles, thermodynamics, cell potentials and EMF series, applications of thermodynamics to corrosion, electrode kinetics, exchange current density, activation polarization, combined polarization, concentration polarization, mixed potential theory, mixed electrodes, passivity forms of corrosion – uniform attack, galvanic corrosion, revise corrosion, pitting, inter granular corrosion and hydrogen damage.

Module 2: (14 hours)

Corrosion control aspects, electrochemical methods of protection – theory of cathodic protection, design of cathodic protection, sacrificial anode, impressed current anode, anodic protection, corrosion inhibitors for acidic neutral and alkaline media , cooling water system – boiler water system organic coating, surface preparation, natural, synthetic resin, paint, formulation and application design aspects in corrosion prevention, corrosion resistance materials.

Module 3: (12 hours)

Corrosion testing, monitoring and inspection, laboratory corrosion test, accelerated chemical tests for studying different forms of corrosion, electrochemical methods of corrosion rate measurements by DC and AC methods, corrosion monitoring methods, chemical and electrochemical removal of corrosion products, newer techniques to study corrosion process, inspection methods by NDT, surface analytical techniques such as AES, ESCA, SEM, evaluation of paints by conventional and electrochemical methods.

References:

1. Roberge P.R., Corrosion Engineering, McGraw Hill, New York, 1999.
2. Fontana, Corrosion Engineering, Int. Student Edn., 3rdEdn., McGraw Hill, 1986.
3. Uhling H.H and Revie R.W., Corrosion Control, John Wiley & sons.INC., 1985.
4. Banerjee S N, Introduction to Science of Corrosion and its Inhibition, Oxonian Inhibitors, Oxonian PressLtd., New Delhi, 2004.
5. Trethewy& Chamberlain, Corrosion for Science and Engineering, Longman Sc& Tech; 2nd revised edition, 1996.

CH3024D POLYMER TECHNOLOGY

Prerequisite: Nil

L	T	P	C
3	0	0	3

Total hours: 39

Course outcomes:

CO 1: Able to understand the basic classifications of polymers, types and kinetics of polymerization

CO 2: Understand the uses and preparations of various polymers

CO 3: Analyze various polymerization techniques

CO 4: Explain the polymer flow properties

CO 5: Illustrate the different techniques used to determine the molecular weight of polymers

CO 6: Describe the various polymer processing techniques and additives used in polymer processing

Module 1 (12 hours)

Introduction, classification of polymers, general properties, addition polymerization, step polymerization, copolymerization, kinetics of polymerization: addition polymerization, free radical, anionic and cationic polymerization, derivation of copolymer equation, techniques of polymerization: bulk polymerization, solution polymerization, suspension polymerization, emulsion polymerization, with merits and demerits of each.

Module 2 (14 hours)

Different types of polymers, natural and synthetic polymers, thermoplastic (polyethylene, polypropylene, polyvinylchloride, polystyrene and co-polymers: PMMA, polycarbonates) and thermosetting polymers (phenol formaldehyde, urea formaldehyde, polyester and epoxy resins, polyurethane), their preparation and applications, analysis of polymer materials, solubility test, copper wire test, specific gravity test, identification of plastic materials. Molecular weight of polymers, number average, weight average, viscosity average molecular weights, experimental methods for molecular weight determination: cryoscopy, ebulliometry, membrane osmometry, light scattering method, viscometry, intrinsic viscosity measurement, gel permeation chromatography.

Module 3(13 hours)

Properties of polymers, rheology, viscous flow, rubber like elasticity, viscoelasticity, hookean elasticity, stress-strain relationship for simple models, Maxwellelement, Voigtelement, stress relaxation and creep, Burger model, melt flow index, capillary rheometer. Processing methods, effect of additives used, plasticizers, colourants, heat stabilizers, antioxidants, ultraviolet absorbers, antistatic agents, flame retardants, blowing agents, fillers etc. Molding techniques for plastics, injection molding, compression molding, calendaring, blow moulding, extrusion, thermoforming, spinning methods for fibres, compounding methods for elastomers, general study of elastomer processing methods.

Reference

1. Fried, J.R., Polymer Science and Technology, Prentice Hall of India Pvt. Ltd., New Delhi, Eastern Economy Edition, 2000.
2. Billmeyer, F.W., Textbook of Polymer Science, Wiley Interscience, 1984.
3. Gowarikar, V.R., Viswanathan, M.V. &Jayadev Sridhar, Polymer Science, Wiley Eastern Ltd., 1988.
4. Premamoy Ghosh, Polymer Science & Technology, Tata Mc. Graw Hill Publishing Company, New Delhi, 2002.

5. Newness, Butterworths and Brydson, J.A., Plastics Materials, London, 1975.
6. Sinha, R., Outlines of Polymer Technology: Manufacture of Polymers, Prentice Hall of India Pvt. Ltd., New Delhi, 2000.

CH3025D FOOD TECHNOLOGY

Pre-requisites: Nil

L	T	P	C
3	0	0	3

Total hours: 39

Course Outcomes:

CO 1: Able to understand the general aspects of food industry; the constituents, quality and standards of food andfood additives.

CO 2: Evaluate heat sterilization kinetics of canned food, containers, metal, glass, flexible packaging.

CO 3: Aware of canning procedures for fruits, vegetables meats, poultry, marine products

CO 4: Learn about preservation by heat and cold, dehydration, concentration, frying, irradiation,microwaveheating, fermentation and pickling.

CO 5: Gain knowledge on packing methods, production and utilization of food products, soft and alcoholic beverages, dairy products, meat, poultry and fish products.

CO 6: Aware of treatment and disposal of food processing wastes.

Module 1: (11hours)

Introduction, general aspects of food industry, role of engineers in food industry, world food demand and Indian scenario; constituents and properties of food,quality and nutritive aspects; food additives, standards, deteriorative factors and their control, preliminaryprocessing methods, food conversion and preservation operation; food processing equipment, food quality, safety and regulations.

Module 2: (14 hours)

Preservation by heat and cold dehydration-freezing and refrigeration, concentration, frying, sterilization and pasteurization, emerging non thermal methods of food preservation, chemicals, fermentation and pickling**,** hurdle technology, food canning technology-heat sterilization of canned food, canning procedures for fruits, vegetables, meats, poultry and marine products; Separation processes in food processing; food packaging, product shelf-life.

Module 3: (14 hours)

Production and utilization of food products-processing of spices and plantation crops; bakery and Confectionery technology, fat and oil processing technology - solvent extraction, refining and hydrogenation of oil, extraction, clarification concentration and packaging of fruit juice; production of jam, candies, pickles, chocolate; diary product processing- meat, poultry and fish processing; beverage processing; treatment and disposal of food processing wastes.

References:

1. J.L. HeidandM.A. Joslyn, Fundamentals of Food Processing Operation, Westport: The AVI Publishing Co., 1967.
2. D.R. Heldman,Food Process Engineering, Westport: The AVI Publishing Co.,1975.
3. C.W. Hall, A.W. Farall and A.L. Rippen,Encyclopedia of Food Engineering, Van Nostrand, Reinhold, 19

CH3026D CERAMIC TECHNOLOGY

Pre-requisites: Nil

L	T	P	C
3	0	0	3

Total hours: 39

Course Outcomes:

CO 1: Understand the need of ceramic materials, their properties, formulation and applications in the modern era

CO 2: Realize the process of synthesizing, characterizing and fabrication of ceramic materials with superior properties.

CO 3: Know the chemical reaction methods of processing ceramics.

CO 4: Understand the importance of glass, refractories, cement and concrete

Module 1: (12 hours)

Introduction to natural and synthetic ceramic materials, traditional ceramics, glaze, glass, refractories, cements and concretes, advanced ceramics. Properties of ceramics: mechanical, thermal, optical, magnetic, and electrical, Body formulation of traditional ceramics: porcelain, terracotta, earthenware, bone china, sanitary ware etc., manufacturing process, properties and uses of whiteware and heavy clayware products, Advanced application of ceramics in novel separation techniques, electronics and electrical industries, automobile industries, defense and armor sectors.

Module 2: (14 hours)

Processing techniques of ceramic raw materials such as size reduction, crushing, grinding, screening, filtration, mixing, conveying and storage of ceramic materials, ceramic fabrication techniques such as sintering- hot pressing, hot isostatic pressing, tape casting, sol-gel processing, extrusion, and vitrification. Different property testing techniques for ceramics, glazes and refractories such as porosity, hardness, density, glaze thickness, thermal conductivity, creep etc. Processing techniques based on reaction methods such as chemical vapor deposition (CVD), vapor phase epitaxy, plasma, enhanced chemical vapor deposition (PECVD), chemical vapor infiltration (CVI), self – propagating high temperature synthesis (SHS) for the preparation of monolithic ceramics, composites, coating, thin films, whiskers and fibres and semi conducting materials such as SI and Gallium arsenide. Total quality control and management in ceramic industries.

Module 3: (13 hours)

Glass formation, structure, raw materials, properties such as thermal, electrical and mechanical, testing and quality control of glass, annealing, glass ceramics, classification of refractory, fundamental properties of refractories and their uses in glass and ceramic industries, special refractories such as cermet, ceramic fibers. Composition, manufacturing process and types of cement and concrete. Testing and quality control of cement.

References:

1. W.D. Kingery, Introduction to Ceramics, New York: John Wiley & sons, 1965.
2. C. Das, S. Bose, Advanced ceramic membranes and applications, Florida: CRC Press, Taylor & Francis, 2017.
3. K.K. Chawla, Ceramic Matrix Composites, 2nd Ed. Boston: Kluwer Academic Publishers, 2003.
4. L.H. Vanvlack, Elements of Material Science and Engineering, 6th Ed. Boston: Addison Wesley, 1989.
5. B.S. Mittchell, An Introduction to Materials engineering and Science: for Chemical and Materials Engineers, New York: Wiley Interscience, 2004.

CH3027D BIOTECHNOLOGY

Pre-requisites: Nil

L	T	P	C
3	0	0	3

Total hours: 39

Course Outcomes:

CO 1: Understand the importance of biotechnology in the present scenario

CO 2: Study the applications of recombinant DNA technology

CO 3: Know the various aspects of fermentation technology and product recovery from fermentation.

CO 4: Explore the application of biotechnology in food and agricultural industries.

CO 5: Able to analyze the role of biotechnology in waste processing and energy generation

Module 1: (16 hours)

Introduction, scope, potential and achievement, enzyme technology, biomass technology.Fermentationtechnology and industrial microbiology, uses, fermenter, downstream processing, role of yeast,solid state fermentation, fermented foods, lactose utilization, single cell protein, enzymes and immobilization ofenzymes, fermentation monitoring and recovery of products.

Module 2: (12 hours)

Plant cell and tissue culture, culture techniques, plant cell fermentation's and production of secondary metabolites,production of secondary metabolites by immobilized plant cells, anther and pollen culture and androgens, geneticengineering of plants, direct gene transfer, cell culture and biotechnology of animals, serum, cell culture assources of valuable products, genetic recombination in mammalian cells and embryos, biotechnology and domesticanimals.

Module 3: (11 hours)

Food and agriculture, processing under exploited plants, petrocrops, aquaculture grain quality, disease resistance,monoclonal antibodies and agriculture, food and feed form wastes, fugal protein, environment and energy:biomass production, bioenergy, biogas, use of micro, organisms in pollution control, hydrogen, waste treatment,biological phosphorous removal from waste water, waste management.

References:

1. H.D.Kumar, A Text Book on Biotechnology, Affiliated East West Press Private Ltd., 1993.
2. J.E. Bailey and D.F. Ollis, Biochemical Engineering Fundamentals, 2nd ed. New Delhi, India: Tata McGraw-Hill International, 1986.

CH3028D FERTILIZER TECHNOLOGY

Pre-requisites: Nil

L	T	P	C
3	0	0	3

Total hours: 39

Course Outcomes:

CO 1: Ability to know the use of fertilizers to improve soil productivity and crop yield.

CO 2: Learn different types of the nitrogenous, phosphatic and potash fertilizers and different organic fertilizer production methods.

CO 3: Develop skills to Formulate and compound fertilizers and Produce fertilizers at the desired rates.

CO 4: Ability to determine the fertilizer requirement for crops in a farm land.

CO 5: Ability to Investigate to ascertain the fertilizer requirement of crops and engineering problems in fertilizer manufacturing.

Module 1: (13 hours)

Chemical fertilizers and organic manures-types of chemical fertilizers, nitrogenous fertilizers, methods of production of ammonia and urea, Nitrogen sources, nitric acid, ammonium sulfate, ammonium sulfate nitrate, ammonium nitrate, ammonium chloride their methods of production, characteristics and storage and handling specifications.

Module 2: (13 hours)

Phosphatic fertilizers, raw materials, phosphate rock, sulfur pyrites, process for the production of sulfuric and phosphoric acids, ground phosphate rock, bone, single super phosphate, triple super phosphate methods of production, characteristics and specifications.

Module 3: (13 hours)

Potash fertilizers, potassium chloride, potassium sulfate, potassium schoenite methods of production, specification, characteristics, complex fertilizers, NPK fertilizers, mono, ammonium phosphate, di, ammonium phosphate, nitro phosphate methods of production.

References:

1. G.H. Collings, Commercial Fertilizers, 5th ed, New York, Mcgraw Hill, 1955.
2. Handbook of Fertilizer Technology, The Fertilizer Association Of India, New Delhi, 1977.
3. A.V. Slacks, Chemistry and Technology of Fertilizers, New York, Interscience, 1966.
4. A. T. George, Shreve's Chemical Process Industries-International Student Edition, 5th ed, McGraw Hill Inc., 1985.
5. G. Rao and R. M. Sittig, Dryden's Outlines of Chemical Technology, 3rd ed, Affiliated East-West Publishers, 1997.

CH3029D OPERATIONS RESEARCH

Pre-requisites: Nil

L	T	P	C
3	0	0	3

Total hours: 39

Course Outcomes:

CO1: Able to understand the characteristics of different types of decision-making environments and the appropriate decision-making approaches and tools to be used in each type

CO2: Able to build and solve Transportation Models and Assignment Models

CO3: Able to design new simple models, like CPM, MSPT to improve decision –making and develop critical thinking and objective analysis of decision problems.

CO4: Able to understand production and personnel management, finance, budgeting and marketing

Module 1 (12 hours)

Linear programming, formulation and graphical solution of LPP's, the general LPP, slack, surplus and artificial variables, reduction of a LPP to the standard form, Simplex computational procedure, Big M method, two-phase method, solution in case of unrestricted variables, dual linear programming problem, solution of the primal from the solution of the dual problems.

Module 2 (10 hours)

Transportation problems, balanced and unbalanced transportation problems, initial basic feasible solution using NW corner rule, row minimum method, column minimum, least cost entry method and Vogel's approximation method, optimal solutions, degeneracy in transportation problems.

Module 3 (17 hours)

Queuing theory, Poisson process and exponential distribution- Network representation of projects, critical path calculation-construction of the time, chart and resource leveling, probability and cost consideration in project scheduling, project control, graphical evaluation and review techniques.

Reference:

1. KantiSwarup, Man Mohan and Gupta, P.K., Introduction to Operations Research, S. Chand and sons, 2005.
2. Pant, J.C., Introduction to Operations Research, Jain Brothers, 2008.
3. Kambo, N.S., Mathematical Programming Techniques, Affiliated East West Press Pvt. Ltd., 2000.

CH3030D HUMAN RESOURCE MANAGEMENT

Pre-requisites: Nil

L	T	P	C
3	0	0	3

Total hours: 39

Course Outcomes:

CO1: Gain an understanding of key terms, theories/concepts and practices within the field of humanresourcemanagement.

CO2: Develop employability skills for the personnel management environment in workplace.

CO3: Develop an ability to undertake qualitative and quantitative research and apply this knowledge inthecontext of an independently constructed piece of work (i.e. dissertation).

CO4: Show evidence of the ability to analyze, manage and problem solve to deal with the challenges and complexities of the practice of collective bargaining.

CO 5: Problem-solve human resource challenges and industrial conflict resolution.

Module 1: (11 hours)

Planning personnel functions - human resource development systems, personnel management environment in India,functions and operations of a personnel office, manpower planning, employee selection and development - recruitment, selection and induction, staff training and development, career planning.

Module 2: (12 hours)

Motivation- job design and appraisal, motivation and productivity, job description, analysis and evaluation,employee motivation and job enrichment, performance monitoring and appraisal, compensation planning - economic background and employee compensation, laws and rules governing employee benefits and welfare,compensation and salary administration.

Module 3: (16 hours)

Managing industrial relations - regulatory mechanisms guiding industrial relations- employee discipline,suspension, retrenchment and dismissal, employee grievance handling.Unions and management- trade unionism, employees' associations, collective bargaining, industrial conflictresolution, industrial democracy and workers participation in management.

References:

1. Rao, T.V. and Pereira, D.F., Recent Experiences in Human Resources Development, Oxford and IBH publishingCo., New Delhi, 1986.
2. Davar, R.S., Personnel Management and Industrial Relations, Vikas Publishing House, New Delhi, 1981.

3. Monappa, Arun and Saiyaddain, Mirza, S., Personnel Management, Tata McGraw Hill, Bombay, 1983.
4. Dasgupta, A., Business and Management in India, Vikas Publishing House, New Delhi, 1974.
5. Yoder, Dale and Paul D. Staudohar, Personnel Management and Industrial Relations, Prentice, Hall,Englewood, Cliffs, 1982.
6. Tripathi, P.C., Personnel Management, S.Chand and Co., Delhi, 1985.
7. Heresy, P. and Blanchard, K.H., Management of Organizational Behaviour, Prentice Hall of India, NewDelhi, 1983.

CH3031D DRUGS AND PHARMACEUTICAL TECHNOLOGY

Pre-requisites: Nil

L	T	P	C
3	0	0	3

Total hours: 39

Course Outcomes:

CO1: Understand the important unit processes involved in drug manufacturing process and their applications.

CO2: Understand the fabrication, design, evaluation and application of drug and its distribution in biological system

CO3: Ability to know factors affecting the bioavailability of drugs and its metabolism

CO4: Know about biogeneric drugs and its manufacturing methods.

Module 1: (12 hours)

Development of drugs and pharmaceutical industry, organic therapeutic agents, uses andeconomics,importantunit processes and their applications,chemical conversion processes, alkylation, carboxylation, condensation, cyclisation, dehydration, esterification, halogenation, oxidation, sulfonation,complex chemical conversions, fermentation

Module 2: (14 hours)

Drug metabolism, physico chemical principles, radio activity, pharma kinetics, action of drugs on human bodies, manufacturing principles, compressed tablets,wet granulation,drygranulation,direct compression, tablet presses formulation, coating pills, capsules sustained action dosage forms, parenteral solutions, oral liquids, injections, ointments, standard of hygiene and manufacturing practice

Module 3: (13 hours)

Vitamins, cold remedies, laxatives, analgesics, nonsteroidal contraceptives, external antiseptics, antacids and others, antibiotics, hormones, vitamins, preservation

References:

1. Rawlines, E.A., Bentleys Text book of Pharmaceutics, 3rd Edn. BailliereTindall, London, 1977.
2. Yalkonsky, S.H., Swarbick, J., Drug and Pharmaceutical Sciences, Vol. I, II, III, IV, V, VI and VII, Marcel Dekker Inc., New York, 1975.
3. Remington’s Pharmaceutical Sciences, Mack Publishing Co., 1975.

CH3032D COLLOID AND INTERFACE SCIENCE

Pre-requisites: Nil

L	T	P	C
3	0	0	3

Total hours: 39

Course Outcomes:

CO1: Understand the basic principles and theories of colloid and interface science.

CO2: Gain knowledge of experimental techniques for characterization of colloids.

CO3: Explain the theoretical and experimental principles underlying various interfacial properties and processes.

CO4: Illustrate various applications of interfaces and colloids..

CO5: Understand the methods ofpreparation, characterization and applications of emulsions.

CO6: Describe the interfacial reactions, biological interfaces and nano-materials.

Module 1: (13 hours)

Introduction to the engineering of interfaces; Definitions of fluid- fluid and fluid-solid interfaces; Occurrence of interfaces in science and engineering; Overview of industrial applications of various interfacial phenomena; Colloidal materials; Properties of colloidal systems; Experimental characterization of colloidal dispersions. Introduction to intermolecular and surface forces; van der Waals forces; Electrostatic double layer force; Disjoining pressure; DLVO theory; Non-DLVO forces.

Module 2: (14 hours)

Surface and interfacial tension; Theoretical methods for the calculation of surface and interfacial tension; Experimental techniques for the determination of equilibrium and dynamic tension; Shape of the surfaces: curvature and radius of curvature; Young-Laplace equation; Kelvin equation; Pendant and sessile drops; Adams-Bashforth equation; Characterization of fluid-solid interfaces; Contact angle and wetting phenomena; Young-Dupre equation; Measurement of equilibrium and dynamic contact angles; Applications of fluid-solid interfaces in crystallization, development of ceramic materials, catalysts, electronic products and nano-materials. Adsorption at fluid-fluid and fluid-solid interfaces; Adsorption of surfactants; Gibbs and Langmuir monolayers; Gibbs adsorption equation: Radiotracer and neutron reflection techniques for studying adsorption at neutron reflection techniques for studying adsorption at fluid-fluid interfaces; Henry, Freundlich, Langmuir, Frumkin and Davies adsorption isotherms; Brunauer-Emmett-Teller theory of adsorption.

Module 3: (12 hours)

Emulsions: Preparation, characterization and applications; Ostwald ripening; Flocculation and coalescence; Micro-emulsions: characterization and properties; Stability of micro-emulsions; Interfacial reactions; Reactions at fluid-solid interfaces; Langmuir-Hinshelwood model; External and internal transport processes; Interfacial polycondensation reactions; Fast and instantaneous Biological interfaces; Adsorption of proteins at interfaces; Biomembranes; Interfacial forces at Biointerfaces; A reactions at fluid-fluid interfaces. Nanomaterials: classification and preparation; Self-assembly; Nanoparticles; Nanowires, nanorods and nanotube; Lithographic techniques; Toxic effects of nano-materials.

References:

1. Adamson,A. W. and Gast,A.P.,Physical Chemistry of Surfaces, John Wiley, New York,1997.
2. Ghosh,P., Colloid and Interface Science,PHI Learning Pvt. Ltd., New Delhi, 2009.
3. Hiemenz,P. C. and Rajagopalan, R.,Principles of Colloid and Surface Chemistry, Marce Dekker NewYork, 1997.
4. Stokes, R. J. and Evans, D. F., Fundamentals of Interfacial Engineering, Wiley-VCH, New York,1997.

CH3033D PROFESSIONAL ETHICS AND HUMAN VALUES

L	T	P	C
3	0	0	3

Prerequisite: Nil

Total hours: 39

Course outcomes:

CO1: Familiar with the legal requirements, ethical issues, and professional issues in the engineering profession.

CO2: Understand the social impact of decisions and actions of participants

CO3: Learn writing short essays and papers related to legal, ethical and professional issues and understand the core values that shape the ethical behaviour of an engineer

CO4: Know about the engineer role and value of engineer in technological development

CO5: Understand social responsibility of an engineer and ethical dilemma while discharging duties in professional life.

Module 1 (11hours)

Human values : morals, values and ethics, integrity, work ethic, service learning, civic virtue, respect for others, living peacefully, caring, honesty, courage, valuing time, co-operation, commitment, empathy, self, confidence, character, spirituality, engineering ethics : sense of 'engineering ethics', variety of moral issued, types of inquiry, moral dilemmas, moral autonomy, Kohiberg's theory, Gilligans theory

Module 2 (14 hours)

Consensus and controversy, models of professional roles, theories about right action, self-interest, customs and region, uses of ethical theories, engineering as experimentation, engineers for responsible experiments, code of ethics, a balanced outlook on law, the challenger case studies, Safety responsibilities and rights, safety and risk, assessment of safety and risk benefit analysis and reducing risk, the Three Miles Island and Chernobyl case studies.

Module 3 (14 hours)

Collegiality and loyalty-respect for authority, collective bargaining, confidentiality, conflicts of interest, occupational crime professional rights employee right, intellectual property rights (IPR) discrimination, Global issues, multinational corporations- environmental ethics, computer ethics weapons development, engineers as managers, consulting engineers as expert witnesses and advisers, moral leadership, sample code of ethics (specific to a particular engineering discipline)

References:

1. M. Martin, and R. Schinzimger, *Ethics in Engineering*. New York: McGraw Hill, 1996.

2. M. Govidarakam, S. Nadarajan and V.S. Senthil Kumar, *Engineering Ethics*. New Delhi: Prentice Hall of India, 2004.

3. C.D Fledermann, *Engineering Ethics*. New Jersey: Prentice Hall, 2004.

4. C.E. Harris, Pritchard and , M.J. Rabins, *Engineering Ethics – Concept and Cases*: Wadsworth Thompson Learning, 2000.

CH4021D BIOCHEMICAL ENGINEERING

Pre-requisites: Nil

Total hours: 39

L	T	P	C
3	0	0	3

Course Outcomes:

CO1:Understand the basic aspects of enzyme and cell structure and its functions.

CO2: Identify approach of chemical engineering with basic life sciences in developing processes and products.

CO3: Analyze the kinetics of enzymatic reactions and their inhibitions.

CO4: Design bioreactor.

Module 1: (13 hours)

Introduction to biochemical engineering, Microorganisms: Types, Structure and function of microbial cells. Biomolecules, Introduction to enzymes, Enzyme kinetics, simple enzyme kinetics, Inhibition of enzyme reactions. Other influences on enzyme activity. Immobilization of enzymes. Effect of mass transfer in immobilized enzyme particle systems. Industrial applications of enzymes.

Module 2: (13 hours)

Cell cultivation: microbial cells, cultivation methods, cell growth measurement, cell immobilization, cell kinetics and fermenter design – Growth cycle for batch cultivation, Stirred-tank fermenter, continuous stirred tank fermenter (CSTF) Multiple fermenters connected in series. Cell recycling.Structured and unstructured Models.

Module 3: (13 hours)

Sterilization methods, batch, continuous and air sterilization, thermal death kinetics, Determination of volumetric mass transfer rate of oxygen from air bubbles and effect of mechanical mixing and aeration on oxygen transfer rate, downstream processing – solid liquid separation, cell rupture, recovery, purification of bio products.

References:

1. J.M. Lee, Biochemical Engineering, New Jersey: Prentice Hall, 1992.
2. J.E. Bailey and D.F. Ollis, Biochemical Engineering Fundamentals, 2nd ed. New Delhi, India: Tata McGraw-Hill International, 1986.
3. M.L. Shuler and F. Kargi, Bioprocess Engineering, Basic Concepts, 2nd ed. New Delhi, India: Prentice Hall of India, 2002.
4. D.G. Rao, Introduction to Biochemical Engineering, 2nd ed. New Delhi, India: Tata McGraw-Hill, 2010.
5. T. Palmer and P.L. Bonner, Enzymes: Biochemistry, Biotechnology, Clinical Chemistry, 2nd ed. Chichester, UK: Horwood Publishing Ltd., 2007.
6. G. Najafpour, Biochemical Engineering and Biotechnology, 2nd ed. Amsterdam, Netherlands: Elsevier Science, 2015.

CH4022D ELECTROCHEMICAL ENGINEERING

Pre-requisites: Nil

L	T	P	C
3	0	0	3

Total hours: 39

Course Outcomes:

CO1: Understand the basics of electrochemistry and the laws associated with it

CO2: Study the role of electrical double layer in electrochemical process

CO3: Describe the mass transfer phenomena in electrochemical systems

CO4: Understand the laboratory techniques to determine rate and mechanism

CO5: Study the classification and understanding the principles of electrochemistry process

CO6: Know the types of electrodes and its use in industry

CO7: Understanding the fundamentals of electrochemical reactors and knowing its applications.

Module: 1 (9 hours)

Review basics of electrochemistry, Faraday's law, Nernst potential galvanic cells, and polarography. The electrical double layer, it's role in electrochemical processes, electro capillary curve, Helmholtz layer, Guoy, Stern layer, fields at the interface.

Module 2: (10 hours)

Mass transfer in electrochemical systems, diffusion controlled electrochemical reaction, importance of convention and the concept of limiting current, over potential, primary, secondary current distribution, rotating disc electrode.

Module 3: (20 hours)

Introduction to corrosion- series, corrosion, Potential - pH diagram, Mixed potential theory, Passivation, Protective coatings, industrial boiler water corrosion control, protective coatings, vapour phase inhibitors, cathodic protection, sacrificial anodes, paint removers.Electro deposition, electro refining, electroforming, electro polishing, anodizing, selective solar coatings, primary and secondary batteries, types of batteries fuel cells. Case study: Electrodes used in different electrochemical industries:Metals, Graphite, Lead dioxide, titanium substrate insoluble electrodes – iron oxide, semi conductingtype etc. Metal finishing, cell design- types of electrochemical reactors, merits of different type of electrochemical reactors.

Reference:

1. Picket, Electrochemical Engineering, Prentice Hall, 1977.
2. Newman, J.S., Electrochemical systems, Prentice Hall, 1973.
3. Barak, M. and Stevenge, U.K., Electrochemical Power Sources – Primary and Secondary Batteries, 1980.
4. Mantell, C., Electrochemical Engineering, McGraw Hill, 1972.
5. Bard, A. J., and L. R. Faulkner. *Electrochemical Methods*. 2nd ed. New York: Wiley, 2000. ISBN: 978047104

CH4023D ENVIRONMENT IMPACT ASSESSMENT AND CLEAN TECHNOLOGY

Pre-requisites: Nil

L	T	P	C
3	0	0	3

Total hours: 39

Course Outcomes:

CO1: Understand the importance, process, procedures and regulatory requirement of EIA and strategic environmental assessment (SEA) towards sustainable development

CO2: Classify impact identification and assessment methods and apply specific methods in specific development projects

CO3: Study and generate impact assessment report for developmental projects and prepare the content of environmental management plan

CO4: Describe the procedure of conducting environmental audits, waste audit and generating reports

CO5: Apply life cycle assessment method to evaluate industrial symbiosis and illustrate the clean technology process and options

Module 1: (10 hours)

Introduction and need for Environmental Impact assessment, Evolution of EIA, legal, policy and regulatory framework, EIA process and methodologies – scoping, screening and establishing baseline conditions, Public involvement in EIA, costs and benefits of EIA, Introduction to Strategic Environmental Assessment.

Module 2: (19 hours)

Application of Environmental impact identification and assessment methods in specific developmental projects- advantages, disadvantages of different methods, applicability of specific methods with examples. EIA report contents for developmental projects like thermal power projects-refinery project, chemical process industries, Impact management and content of environmental management plan. Review of EIA quality, Decision making.

Module 3: (10 hours)

Implementation and follow up - environmental audit, waste audit, Life cycle assessment - industrial symbiosis, clean technology options - clean technology and clean up technology - materials reuse, waste reduction at source and clean synthesis.

References:

1. Environmental Impact Assessment: Theory and Practice: Unwin Hyman Ltd., 1988.
2. Environmental Health and Safety Auditing Hand Book. New York: McGraw Hill Inc., 1994.
3. W. C. Larry, Environmental Impact Assessment: McGraw Hill Book Company, 1997.
4. R.C Kirkwood, and A.J Longley, Clean Technology and Environment: Chapman &Hall, 1995.

CH4024D PROCESS AUTOMATION

Pre-requisites: CH3004DPROCESS AUTOMATION

L	T	P	C
3	0	0	3

Total hours: 39

Course Outcomes:

CO1: Knowledge of the different component of process automation in chemical process industries

CO2: Knowing the hardware elements in the instrumentation systems

CO3: Understanding of the conventional and advanced control schemes used in process industry

CO4: Understanding the automated operation of batch and continuous plants

CO5: Knowledge of the process data management tools and statistical process control

Module 1: (12 hours)

Introduction – Chemical plant- modern chemical process control engineering practice and automation, capital project management, project team considerations, principles of measurement and classification of control instruments, instrumentation symbols and diagrams

Module 2: (14 hours)

Single loop regulatory control and its enhancements, general feed-back control, PID controller and its tuning, user interface considerations, cascade control, feed forward control, ratio control, split, range control, override control, single loop model predictive control, Multivariable regulatory control-multi loop control, decoupling control, singular value decomposition (SVD)analysis.

Module 3: (13 hours)

Multivariable model predictive control, user interface, discrete and interlock control, z, transforms, batch plant operation complexity, batch operation control, procedural control in batch processing, co-ordination and recipe control, batch data management, and statistical process control, batch user interface for setup and operation, case study

References:

1. T. E. Kelvin, and L. H. John, *Plant wide Process Control*: Wiley Series in Chemical Engineering, 1999.
2. L. Jonathan, *Process Automation Hand Book: A Guide To Theory and Practice*: Springer Publications, 2007.
3. M. L. Luyben, and W.L. Luyben, *Essentials of Process Control*: McGraw-Hill, 1996.

CH4025D NEW ENTREPRISE CREATION AND MANAGEMENT

Pre-requisites: Nil

L	T	P	C
3	0	0	3

Total hours: 39

Course Outcomes:

CO 1: Understand the role of Entrepreneur and entrepreneurship in economic development, entrepreneurial competencies and institutional interface

CO 2: Establish and operate the small scale enterprises and analyze the various issues in SSE

CO 3: Examine the elements of Business Planning and structuring and create a successful business plan for an entrepreneurial start-up.

CO4: Understand the concept of management performance assessment and control, and formulate relevant and efficient strategies for stabilization and growth of business.

CO 5: Develop the strategies for managing family enterprises

Module 1: (11hours)

Entrepreneur and entrepreneurship - entrepreneurship and small scale enterprise (SSE), role in economicDevelopment, entrepreneurial competencies and institutional interface.

Module 2: (14 hours)

Establishing the small scale enterprise - opportunity scanning and choice of enterprises, market assessment for SSE, choice of technology and selection of site, financing the new / small enterprises, preparation of the business plan, ownership structures and organizational framework; Operating the small scale enterprises, financial management issues in SSE, operations management issues in SSE, marketing management issues in SSE, organizational relations in SSE, case studies

Module 3: (14 hours)

Performance appraisal and growth strategies - management performance assessment and control, strategies for stabilization and growth, managing family enterprises.

References:

1. Holt, *Entrepreneurship – New Venture Creation*: Prentice Hall India Pvt. Ltd., 2001.
2. K. Madhulika, *Management of New & Small Enterprises*: IGNOU course material.
3. B.S. Rathore, and S. Saini, *Entrepreneurship Development Training Material*.Chandigarh: TTTI, 1988.
4. P.C. Jain, *A Hand Book for New Entrepreneurs, Faculty and External Experts*. Ahmedabad: EDII, 1986.
5. J.B.Patel, and D.G.Appampalli, *A Manual on How to prepare a Project Report.* Ahmedabad: ED II,1991.
6. J.B.Patel, and S.S. Modi, *A Manual on Business Opportunity Identification and Selection.* Ahmedabad: ED II, 1995.

CH4026D SPECIALITY POLYMERS

L	T	P	C
3	0	0	3

Prerequisite: Nil

Total hours: 39

Course outcomes:

CO 1: Identify high temperature and fire resistant polymers based on their chemical structure

CO 2: Describe the methods to improve the fire resistance of polymers

CO 3: Explain the conducting, photoconducting mechanisms of polymers

CO4: Explain the construction of sheathing materials used in telecommunication and optical cables

CO5: Choose polymers for biomedical and polymer concrete applications

CO 6: Describe the properties of high modulus fibers and hydrophilic polymers

Module 1 (12 hours)

High temperature and fire resistant polymers, improving low performance polymers for high temperature use, polymers for low fire hazards, polymers for high temperature resistance, fluoropolymers, aromatic polymers, hydrocarbon polymers, polyphenylenesulphide,polysulphones, polyamides, polyketones, heterocyclic polymers.

Module 2 (14 hours)

Polymers with electrical and electronic properties; conducting polymers, conducting mechanism, polyacetylene, polyparaphenylene, polypyrrole, photoconducting polymers, polymers in non- linear optics; polymers with piezoelectric, pyroelectric and ferroelectric properties, photoresists for semiconductor fabrication.
Polymers in telecommunications and power transmission, polymers as insulators, electrical breakdown strength, capacitance, dielectric loss, polymers in telecommunication, cable insulation, low fire risk materials, polymers in power transmission, optical fibre telecommunication cables.

Module 3 (13 hours)

Hydrophilic polymers: natural, semi synthetic and synthetic, polymer concrete-polymer impregnated concrete, ultra-high modulus fibers, polymers for biomedical applications

References:

1. Mark, H.F. (Ed.), Encyclopedia of Polymer Science & Engineering, John Wiley & Sons, New York, 1989.
2. Martin T Goosey, Plastics for Electronics, Elsevier Applied Science Publishers, 1985.
3. Dyson, R.W. (Ed.), Specialty Polymers, Springer US, 1987.

CH4027D PROCESS MODELING AND SIMULATION

Pre-requisites: CH3007DPROCESS MODELING AND SIMULATION

L	T	P	C
3	0	0	3

Total hours: 39

Course Outcomes:

CO 1: Demonstrate the applications of process modeling and simulation in chemical engineering, its usefulness and limitations

CO 2: Develop various chemical engineering process models based on fundamental laws

CO 3: Identify and develop skills for the solution of process models

CO 4: Model and solve various real life chemical engineering process using MATLAB and interpret simulation results

Module 1: (13 hours)

Introduction to process modelling and simulation, its usefulness and limitations, classification of models, mathematical complexity and scale, fundamental laws on which models are build- conservation laws; chemical reaction engineering; thermodynamics; transport phenomena; equations of state; equilibrium, model building, types of variables and degrees of freedom analysis. Development of isothermal and non-isothermal models for various process units- stirred tank; jacketed vessel; surge tank; heat exchangers, packed column; reactors, mixing tank; absorption column; multi-component flash drum and distillation column.

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Module 2: (14hours)

Solution techniques for steady state and unsteady sate lumped parameter models which leads to algebraic and ordinary differential equations (initial value problems) - explicit Euler method; implicit Euler method; Runge-Kutta methods; Solution techniques for steady state and unsteady sate distributed parameter models which leads to ordinary differential equations (initial value problems and boundary value problems with Dirichlet, Neumann and Robin and mixed boundary conditions), and partial differential equations (implicit and explicit method, Crank-Nicolson method).

Module 3: (12 hours)

Linearization of models, state space models, system stability, Introduction to MATLAB, Simulation of the process models for various units of plant and operations using MATLAB, step-size strategies, convergence criteria, analysis and interpretation of simulation results.

References:

1. B.W. Bequette, Process Dynamics: Modeling, Analysis and Simulation, New Jersey, Academic press, 2001

2. William L. Luyben, Process Modeling, Simulation and Control for Chemical Engineers, 2nd edition McGraw-Hill Publisbing Company, New York, 1999
3. B. Ogunnaike and W. Haemon Ray Process Dynamics, Modeling and Control, Oxford University Press Oxford, 2006
4. Hussain Chemical Process Simulation, Wiley & Sons, INC. New York, 1986
5. S.C. Chapra and R.P. Canale, Numerical Methods for Engineers, 7thedition McGraw-Hill Education New York, 2015
6. R.E.Franks, Modeling and Simulation in Chemical Engineering, John Wiley, 1972.
7. A.W. Westerberg, H.P. Hutchison, R.L. Motard, P. Winter, Process Flowsheeting, Cambridge University Press Cambridge 1979

CH4028DMEMBRANE TECHNOLOGY

Pre-requisites: Nil

L	T	P	C
3	0	0	3

Total hours: 39

Course Outcomes:

CO 1: list various membranes, materials and membrane fabrication methods.

CO2: Describe the working principles of various membrane separation processes and membrane modular operations.

CO3: Design membrane separation process systems - reverse osmosis, microfiltration, ultrafiltration, pervaporationand gas permeation.

CO 4: Discuss the working principles of membrane reactor, membrane distillation and membrane extraction.

Module 1: (14 hours)

Introduction, classification, membrane processes, principle, membranematerials, membrane preparation techniques: isotropic membranes, anisotropic membranes, metal membranes, ceramic membranes, liquid membranes and biomembranes. Membrane modules: plate and frame, spiral wound, tubular and hollow fiber, applications.

Module 2: (13 hours)

Mechanism of liquid separation membrane processes, RO/MF/UF transport, solution diffusion model, pore flow model, resistance model, boundary layer film model, design equations, concentration polarization, membrane fouling and cleaning, engineering aspects of membranes, cascade operation, examples of cascade operation, applications.

Module 3: (12 hours)

Pervaporation andgas separation, principle, dual sorption model, free volume theory, complete mixing model for gas separation, cross flow model, counter current flow model, process design, applications. Membrane contactors, membrane reactor, membrane distillation, membrane extraction, applications.

References:

1. R. W. Baker, Membrane Technology and Applications, 2nd ed. Chichester, UK:John Wiley & Sons Ltd., 2004.
2. Christie J. Geankoplis, Transport Processes and Unit Operations, 3rd ed., New Jersey: Prentice Hall Inc., 1993.
3. W.L. McCabe, J.C. Smith and P. Harriot, Unit Operations of Chemical Engineering, 7th ed. New York: McGraw-Hill, 2005.
4. B.K.Dutta, Principles of Mass Transfer and Separation Processes, New Delhi, India: Prentice Hall of India Pvt. Ltd., 2007.
5. J.D. Seader, E.J. Henley and D.K. Roper,Separation Process Principles, 3rd ed. New Jersey: John Wiley & Sons Inc., 2011.
6. J.M. Coulson and J.F. Richardson, Chemical Engineering: Particle Technology and Separation Processes Vol.2, 5th ed. Oxford,UK:Butterworth-Heinemann, 2002.
7. E.Drioli andL.Giorno, Encyclopedia of Membranes, Berlin, Germany: Springer, 2016.
8. S.T. Hwang and K.Kammermayer, Membranes in Separations, New York: John Wiley and Sons,1975.

CH4029D MATHEMATICAL METHODS IN CHEMICAL ENGINEERING

Pre-requisites: Nil

L	T	P	C
3	0	0	3

Total hours: 39

Course Outcomes:

CO1: Identify linear and non-linear algebraic equations evolving in chemical engineering and develop skills to solve them numerically.

CO2: Identify ordinary differential equations evolving in chemical engineering and develop skills to solve them numerically

CO3:Identify partial differential equations evolving in chemical engineering and develop skills to solve them numerically

CO4: Develop skills to select the appropriate numerical technique and solve given chemical engineering problems using MATLAB

Module 1: (12 hours)

Solution techniques for linear algebraic equations: direct solution techniques- Cramer's rule; Gaussian elimination and LU decomposition, Solution of sparse linear systems- tridiagonal; bond diagonal and block diagonal matrix, Iterative solution techniques- Jacobi method; Gauss-Seidal method and Relaxation method, solution techniques for non-linear single variable algebraic equation- direct substitution; bisection method; Reguli-Falsi method and Newton-Raphson method, solution techniques for multi-variable algebraic equations- Newton-Raphson method and Quasi-Newton method, solving linear and non-linear algebraic equations evolving in chemical engineering using MATLAB

Module 2: (15 hours)

Solution techniques for ordinary differential equations: Initial value problems- explicit methods; implicit methods; predictor corrector methods and Runge-Kutta methods, stability, multistep methods, stiffness, systems of ordinary differential equations, step-size strategies, Boundary value problems- Initial value methods- shooting methods, multiple shooting superposition; finite difference methods- piecewise polynomial functions, linear and non-linear problems with Dirichlet, Neumann and Robin boundary conditions, finite element methods- Galerkin; collocation, solving ordinary differential equations evolving in chemical engineering using MATLAB

Module 3: (12 hours)

Solution techniques for parabolic differential equations: classification and characterization of linear partial differential equations, orthogonal functions and Sturm-Liouville conditions, method of lines, finite difference- Crank-Nicolson method, Finite elements- Galerkin, orthogonal collocation, solving partial differential equations evolving in chemical engineering using MATLAB

References:

1. S.C. Chapra and R.P. Canale, Numerical Methods for Engineers, 7th ed., New York: McGraw-Hill Education, 2015.
2. M.E. Davis, Numerical Methods and Modeling for Chemical Engineers, New York: John Wiley & Sons, Inc., 1984.

3. S. Pushpavanam, Mathematical Methods in Chemical Engineering, New Delhi: Prentice Hall India Pvt Ltd, 2004.
4. R.G. Rice and D.D. Do, Applied Mathematics and Modeling for Chemical Engineers, New York: John Wiley & Sons, 1995.
5. C.M. Bender and S.A. Orszag, Advanced Mathematical Methods for scientists and Engineers, New York: McGraw-Hill Company, 1999.

CH4030D COMPUTATIONAL FLUID DYNAMICS

Prerequisite: CH2003D, CH2006DCOMPUTATIONAL FLUID DYNAMICS

L	T	P	C
3	0	0	3

Total hours: 39

Course outcomes:

CO1:Familiar with the different differential equations for flow phenomena and numerical methods for their solution.

CO2:Familiar with the different discretization methods using finite volume method.

CO3:Learn how to formulate and solve computational problems arising in the flow of fluids.

Module 1: (12 hours)

Introduction to partial differential equations, classification of physical behavior, governing equations of fluid flow and heat transfer – continuity equation, Navier-Stokes equation, energy equation, classification of fluid flow equations, auxiliary conditions for viscous fluid flow equations, Introduction to turbulent flow, time averaged Navier-Stokes equation, turbulence models – mixing length model, $\kappa -$ model, Reynolds stress equation model.

Module 2: (15 hours)

The finite volume method for diffusion problems – introduction, one dimensional steady state diffusion problems, two dimensional diffusion problems, three dimensional diffusion problems, discretized equations for diffusion problems, boundary conditions, the finite volume method for convection-diffusion problems – steady one dimensional convection and diffusion, the central differencing scheme, properties of discretisation schemes – conservativeness, boundedness, transportiveness, assessment of the central differencing scheme for convection-diffusion problems, the upwind differencing scheme, the hybrid differencing scheme, the power, law scheme, higher order differencing schemes for convection-diffusion, quadratic upwind differencing scheme, boundary conditions, solution algorithms for pressure velocity coupling in steady flows.

Module 3: (12 hours)

The finite volume method for unsteady flows and implementation of boundary conditions – one dimensional unsteady heat conduction, discretisation of transient convection-diffusion equation, solution procedures for unsteady flow calculations, implementation of inlet, outlet and wall boundary conditions, constant pressure boundary condition, practical exposure to CFD software package for solving fluid flow and heat transfer problems.

Reference:

1. H. K. Versteeg and W. Malalasekera, *An Introduction to Computational Fluid Dynamics: The Finite Volume Method*: Longman Scientific & Technical publishers, 2007
2. D. A. John, *Computational fluid dynamics: The Basics with Applications.* New York: McGraw, Hill, 1995.
3. V. R. Vivek, *Computational flow modeling for chemical reactor engineering.* San Diego*:* Academic Press, 2002.
4. S. V. Patankar, *Numerical heat transfer and fluid flow*: Hemisphere Publishing Corporation, 1980.

CH4031D MICRO ELECTRONICS PROCESSING

Prerequisite: Nil

L	T	P	C
3	0	0	3

Total hours: 39

Course outcomes:

CO1: Able to design, simulate, built and debug complex combinational and sequential circuits based on an abstract functional specification.

CO2: Able to know semiconductor processing, device design, device operation, and circuit integration.

CO3: Develop skills in manufacturing practices of novel semiconductor devices, MEMS, photonics, and nanoscale devices

CO4:Understand the carrier concentrations for semiconductor materials under a variety of conditions.

Module 1 (13 hours)

Integrated circuits – semiconductors and charge carriers- basic relationships and conductivity, basic units of integrated circuits, broad view of microelectronics processing, silicon refining and other raw materials, metallurgical grade and electronic grade silicon, metal organic compounds, Bulk crystal growth, crystal structures and defects, crystal growth and impurity distribution, oxygen precipitation.

Module 2 (13 hours)

Chemical rate processes in the fabrication of ICs, growth processes of films of crystalline structure, heterogeneous reactions and deposition kinetics, Chemical vapour deposition reactors, regimes of fluid flow, intrinsic kinetics and transport effects, reactor design, isothermal, non-isothermal and molecular flow reactors.

Module 3 (13 hours)

Incorporation and transportation of dopants – dopant incorporation, radiation damage and annealing, dopant redistribution and auto doping, lithography – illumination and pattern transfer, resists and resist development, yield and ultimate limits, physical and physicochemical rate processes , evaporation and physical vapour deposition, plasma, physical sputtering, plasma deposition and gas, solid reaction, plasma etching, physical vapour deposition apparatuses, plasma reactors.

References:

1. H.H. Lee, *Microelectronics Processing*: McGraw Hill, 1990.

CH4032D RISK ANALYSIS AND HAZOP

Pre-requisites: Nil

L	T	P	C
3	0	0	3

Total hours: 39

Course Outcomes:

CO1:Acquire knowledge to ensure safety and manage risk in chemical industries.

CO2: Understand the risk analysis, targets and contingencies, and risk mitigation strategies.

CO3: Ability to Identify hazards and affects in chemical industries.

CO4:Develop skills to estimate risks and apply a control measure hierarchy to control risks.

CO 5: Know about the safe working procedures and able to conduct assessment and produce safe operational working procedure in industries and research laboratories.

Module 1: (15 hours)

Introduction, quantitative risk assessment, rapid risk analysis, comprehensive risk analysis, emission and dispersion, leak rate calculation, single and two phase flow dispersion model for dense gas, flash fire, plume dispersion, toxic dispersion model and evaluation of risk,radiation tank on fire flame length, radiation intensity calculation and its effect on plant, people and property, radiation VCVCE, explosion due to over pressure, effects of explosion, risk contour , effects, explosion, BLEVE, jet fire, fire ball.

Module 2: (11 hours)

Overall risk analysis, generation of meteorological data, ignition data, population data, consequence analysis and total risk analysis, overall risk analysis, overall risk contours for different failure scenarios, disaster management plan, emergency planning, onsite and off, site emergency planning, risk management, ISO 14000, EMS models case studies, marketing terminal, gas processing complex, refinery.

Module 3: (13 hours)

Hazard identification safety audits, checklist, 'what if' analysis, vulnerability models event tree analysis, fault tree analysis, hazard past accident analysis, Fixborough, Mexico, Madras, Vizag, Bhopal analysis, hazop guidewords, parameters, deviation, cause, consequences, recommendation, coarse hazop study, case studies, pumping system, reactor, mass transfer system.

References:

1. K.V. Raghavan and A.A. Khan*, Methodologies in Hazard identification and AssessmentManual:* CLRI publication 1990.
2. V.C. Marcel, *Major Chemical Hazard.* Chi Chester, UK: Ellis Hawood Ltd., 1987.
3. B. Skeleton, *Process Safety Analysis:* U.K., Institution of Chemical Engineers, 1997.
4. A. C. Daniel and J.F. Louvar, *Chemical Process Safety: Fundamentals with Applications*. NJ: Prentice Hall, 1990.
5. R. Marvin, *Risk Assessment - theory, methods, and applications*: Wiley, 2011.
6. W. Geoff, *Major hazards and their management*: Institution Of Chemical Engineers, 1997.
7. P. L. Frank, *Loss Prevention in the Process Industries*: Reed Educational and Professional Publishing, 1996.

CH4033D NOVEL SEPARATION TECHNIQUES

Pre-requisites: Nil

L	T	P	C
3	0	0	3

Total hours: 39

Course Outcomes:

CO1: Identify various conventional and modern separation techniques in chemical engineering processes

CO2: Understand the fundamentals of membrane separation and charged based separation techniques and able to analyze and design of different membrane modules for intended applications

CO 3: Realize the difference between conventional and novel separation techniques

CO 4: Ability to apply the knowledge of different separation techniques for novel applications

Module 1: (13 hours)

Overview of conventional separation processes such as adsorption, ion exchange, chromatography and counter current separations, pressure swing adsorption, thermal swing adsorption, fixed-bed adsorption, adsorption equilibrium, ion exchange equilibria, ion exchange cycle, affinity chromatography, gradient chromatography, Super critical fluid extraction, physicochemical principles, thermodynamics, process synthesis and energy analysis, separation by thermal diffusion.

Module 2: (13 hours)

Membrane separation processes, classification, structure & characteristics of membranes, thermodynamic considerations, mass transfer considerations, design of UF, MF, NF, RO, per-evaporation, gaseous separations and dialysis. Membrane fabrication and characterization techniques.

Module 3: (13 hours)

Surfactant based separations, fundamentals of surfactants at surfaces & in solutions, liquid membrane permeation, foam separations, micellar separations, external field induced separations electric & magnetic field separations, centrifugal separations, electrophoresis.

References:

1. P.C. Wankat, *Large Scale Adsorption Chromatography*: CRC press, 1986.
2. R.W. Rousseu, *Handbook of Separation Process Technology*: John Wiley & Sons, 1987.
3. Y. Tanaka, *Ion Exchange Membranes*: Fundamentals and Applications (Membrane Science and Technology), Elsevier Science, 2015.
4. J.F. Scamehorn, H.J Harwell, *Surfactant-Based Separation Processes*: Surfactant Science Series Volume 33, CRC Press, 1989.
5. J. Mulder, *Basic Principles of Membrane Technology*: Springer, 1996.
6. S.T. Sorensen, *Surface Chemistry and Electrochemistry of Membranes*: CRC Press, 1999.

CH4034DPROJECT ENGINEERING

Pre-requisites: NIL

L	T	P	C
3	0	0	3

Total hours: 39

Course Outcomes:

CO 1: Bridges boundaries between engineering and chemical industry management.

CO 2: Provide the students with a basic understanding and importance of design of chemical plants.

CO 3: Understand the responsibilities of project engineer, which includes schedule preparation, pre-planning and resource forecasting for engineering and other technical activities relating to the project.

CO 4: Understand the details of engineering design and equipment selection- design calculations and process equipment.

Module 1: (12 hours)

Scope of project engineering, the role of project engineer, R&D, TEFR, plant location and site selection, preliminary data for construction projects, process engineering, flow diagrams, plot plans, engineering design and drafting.

Module 2: (12 hours)

Planning and scheduling of projects- bar chart and network techniques, PERT, CPM, Crashing project, procurement operations, office procedures, contracts and contractors, project financing, statutory sanctions.

Module 3: (15 hours)

Details of engineering design and equipment selection- design calculations excluded vessels, heat exchangers, process pumps, compressors and vacuum pumps, motors and turbines, other process equipment, Piping design- thermal insulation and buildings, safety in plant design, plant constructions, start up and commissioning, design calculations excluded.

References:

1. M.Rase and J.Barrow, *Project Engineering of Process Plants*: John Wiley, 1974.
2. Y. Brounell and C. Young, *Process Equipment Design*: Willey, 2009.
3. F. Plummer, *Project Engineering*: Elsevier, 2007.

CH4035D FUEL CELLS

Prerequisite: Nil

L	T	P	C
3	0	0	3

Total hours: 39

Course outcomes

CO 1: Apply fundamentals of thermodynamics, electrochemistry, heat transfer, mass transfer, and fluid mechanics principles to design and analysis of this fuel cell technology.
CO 2: Understanding of performance behavior, operational issues and challenges for all major types of fuel cells.
CO 3: Identify, formulate, and solve problems related to fuel cell technology keeping in mind economic viability.
CO 4: Identify and design the ancillary components needed for an integrated fuel cell system.

Module 1 (13 hours)

Introduction to fuel cells, differences between a battery and a fuel cell, advantages, historical aspects, types of fuel cells, electrochemistry basics, double layer phenomena, electrochemical equilibrium, reaction kinetics, efficiencies, thermodynamics fuel cell systems, physical nature of thermodynamic variables, heat of formation, sensible enthalpy, and latent heat, determination of change of enthalpy for non-reacting species and mixtures, thermodynamic efficiency of a fuel cell.

Module 2 (13 hours)

Transport phenomena in fuel cell systems, ion transport in an electrolyte- electron transport, gas phase mass transport, single phase flow in channels, multiphase mass transport in channels and porous media, heat generation and transport, design of fuel cell systems-single cell assembly, auxiliary units.

Module 3 (13 hours)

Modeling of fuel cells- linear and nonlinear models of fuel cell dynamics, experimental methods, equipment and methods,fuel processing, handling and production of hydrogen, applications of fuel cells in vehicles, utility power systems and standalone systems

Reference

1. Barbir, F., PEM Fuel cells : Theory and Practice, 2ndEdn., Elsevier, 2012
2. Larminie, J. and Dicks, A. Fuel cell systems explained, John Wiley & Sons England, 1st Ed. 2006
3. Mench, M. M, Fuel cell engines, John Wiley & Sons New Jersey, 2008
4. Gou, B., Na, K. W., and Diong, B., Fuel cells: Modeling, Control and Applications, CRC Press, 2010
5. Spiegel, C., PEM Fuel Cell Modeling and Simulation Using MATLAB, 1STEdn, Academic Press, 2008.

CH4036D COMPOSITE MATERIALS

L	T	P	C
3	0	0	3

Prerequisite: Nil

Total hours: 39

Course outcomes:

CO 1: Identify the properties of fiber and matrix materials used in commercial composites

CO 2: Explain the different methods for the preparation of FRP

CO 3: Understand the micromechanics in polymer composites

CO 4: Identify and select materials and processing methods for different applications

CO 5: Assess the quality of polymer composites

Module 1 (13 hours)

Introduction to composite materials, definitions and basic concepts, classification, type of composite materials, characteristic features and advantages of composite materials, reinforcement and matrix materials and their properties, glass, carbon, Kevlar, boron, asbestos, steel, natural fibres and whiskers, reinforcement fibres, different types and forms used in FRP, surface treatment for fibres, size and coupling agents, commonly used fibres and additives in FRP and their effects, various types of resins used, polyester resins, epoxy and phenol formaldehyde resins. FRP processing, important methods: hand lay-up, spray up, filament winding (polar and helical), pressure bag moulding, autoclave moulding, vacuum bag moulding, centrifugal casting, pultrusion, advantages and disadvantages, manufacture and properties of moulding compounds, prepregs and performs, fabrication of products using them,

Module 2 (15 hours)

Fibre Reinforced Thermoplastics (FRTP) preparation, brief description of coating process, melt compounding process and dry blending process, injection moulding, rotational moulding and cold forming of reinforced thermoplastics.
Theory of reinforcement, selection criterion of matrix and reinforcement mechanics of composite materials, mechanism of load transfer, minimum and critical fibre content, critical fibre length, law of mixture rule, unidirectional, bidirectional and random fibre composites, effect of fibre orientation on stiffness and strength, concept of unit cell, stress analysis of unit cells, toughness of fibrous composites, microscopic stress, strain curves.

Module 3 (11 hours)

Testing of composite materials and products for quality control: testing of glass fibre, resins and products, general design considerations, design values, factor of safety, working stress approach, service ability design, selection of materials and processing methods, application of composite of materials in various fields.

Reference

1. Peters, S.T,(Ed)., Handbook of Composites, 2nd Edn., Springer, 1998.
2. Mohn. J.G., Oleesky, S.S., SPI Handbook of Technology and Engineering of Reinforced Plastics/ Composites, 2ndEdn., Van Nostrand, 1973.

3. Richardson M.O.W., (Ed.), Polymer Engineering Composites- Applied Science Publishers Ltd, London, 1977.
4. Lubin G., Handbook of Composites, 2nd Edn., Springer US, 1982.

CH4037D SAFETY IN CHEMICAL INDUSTRIES

Pre-requisites: Nil

L	T	P	C
3	0	0	3

Total hours: 39

Course Outcomes:

CO1: Anticipate, recognize, and evaluate hazardous conditions and practices affecting people, property and the environment, develop and evaluate appropriate strategies designed to mitigate risk.

CO2: Understand the importance of plant safety and safety regulations, different types of plant hazards and their control, personal protective equipment, principles and procedures of safety audit.

CO3: Ability to do Hazard analysis, Risk assessment techniques (HAZOP, HAZAN, Fault Tree Analysis, Consequence Analysis), Onsite and offsite emergency management, Human error Analysis and Accident Analysis.

CO4: Recognize that the practice of safety requires ongoing learning, and undertake appropriate activities to address this need.

Module 1: (14 hours)

Introduction, safety program, engineering ethics, accident and loss statistics: acceptable risk, public perception, chemical hazards , toxic chemicals, dust, gases, fumes, vapours and smoke, the concept of threshold limits, acute and chronic exposure effects, personal monitoring, biological sampling, control measures, UN and other classification of chemicals, transportation of chemicals, receiving and storing chemicals, HAZCHEM Code, work permit systems, pipe lines in chemical factories, colour coding of chemical pipe lines.

Module 2: (12 hours)

Run away reactions, control, precaution and prevention, inherent safety, emergency planning, on, site and off, site emergency planning, emergency preparedness, rehearsal and exercises, Mood's toxicity index, inspection techniques for plants, reaction vessels, check list for routine checks, checklist for specific maintenance and breakdown.

Module 3: (13 hours)

Fires and explosions, fire triangle, distinction between fires and explosions, definitions, flammability characteristics of liquids and vapours, designs to prevent fires and explosions, inerting, explosion proof equipment and instruments, ventilation, sprinkler systems, risk assessment, hazard vs. risk, techniques for risk assessment, HAZOP, HAZAN, fault tree analysis, past accident analysis, FMEA, quantitative risk assessment.

References:

1. Crowl, D.A. and Louva, J.F., Chemical Process Safety (Fundamentals with Applications), Prentice Hall, 2001.
2. Fawcett, H.H. and Wood, W.S., Safety and Accident Prevention in Chemical Operations, 2nd edition, John Wiley & Sons, New York, 1982.
3. Sinnot, R.K., Chemical Engineering, Volume, 6, Butterworth Coulson and Richardson's Heinnann Ltd.
4. Accident Prevention Manual for Industrial Operations, Vol I & II, NSC Chicago, 1982.

5. Irving, S.X., Dangerous Properties of Industrial Materials, 1968.
6. Lees, F.P., Loss Prevention in Process Industries, Butterworths, NewDelhi, 3rd Edn., 2005.

ZZ1093D PHYSICAL EDUCATION

L	T	P	C
1	0	1	1

Course Outcomes

CO1: Select a game/ activity of his/ her choice to pursue on the campus to enjoy/ entertain and thereby develop good health and fitness which he/she would carry over to post-campus life for maintaining health, fitness and wellness.
CO2: Be more proficient in a game, which may lead him/her to a berth in the institute teams.
CO3: Gain exposure to professional training,so as to enable him / her to excel in sports activities.
CO4: Participate in intramural and open mass participation activities.
CO5: Participate and organise in-campus or off-campus sports activities.

UNIT – I - Introduction, definition, aims & objectives of Physical Education.Health, Physical fitness and wellness.Importance, scope and relevance of Physical Education in NITC curriculum.

UNIT – II - Physical fitness and components. Health related Physical fitness and components. Benefits of exercise – physical and physiological.

UNIT – III - Physical exercise and its principles.Activities for developing physical fitness – walking, jogging, running, weight training, stretching, yogasanas.Athletic injuries and their management.Nutritional balance.

UNIT – IV - Motivation and its importance in sports.Stress, anxiety, tension, aggression in sports.Personality, self-confidence and performance.Team cohesion and leadership in sports.

UNIT – V - Lifestyle diseases and its management, Diabetes and Obesity, Hypertension, Osteoporosis Coronary heart diseases and cholesterol.Backpain, Postural deformities and their remedies.

UNIT – VI. - Olympic Values Education.Event & Crisis management.

References

1. Najeeb, A. M., Atul, M., Sumesh, D. and Akhilesh, E. (2015), “Fitness Capsule for university curriculum”.

ZZ1094D VALUE EDUCATION

L	T	P	C
1	0	1	1

Course Outcomes

1. Identify the purpose of education and the problems faced by mankind, in terms of socio economic and environmental issues.
2. Describe the social and intellectual needs to transform the society to a better one where everyone meets the basic economic and social security, freedom and atmosphere to live a meaningful life.
3. Practise a meaningful life avoiding all kinds of corrupt practices and develop unconditional love, universal brotherhood and simulate international peace and prosperity.
4. Persuade others to practise a righteous life, which would stimulate a synergy of universal harmony and peace.
5. Create an ideal society where everyone enjoys the fruits of love, peace and harmony.

Unit I(3 hours): **Social Justice** Definition –need-parameters of social justice –factors responsible for social injustice –caste and gender –contributions of social reformers.

Unit II(5 hours)**: Human Rights and Marginalized People** Concept of Human Rights-Principles of human rights-human rights and Indian Constitution-Rights of Women and children-violence against women –Rights of marginalized People-like women, children, dalits, minorities, physically challenged etc.

Unit III(5 hours): **Social Issues and Communal Harmony** Social issues–causes and magnitude-alcoholism, drug addiction, poverty, unemployment etc.-communal harmony-concept-religion and its place in public in public domain-separation of religion from politics-secularism role of civil society.

Unit IV(5 hours): **Media Education and Globalized World Scenario** Mass media-functions-characteristics-need and purpose of media literacy-effects and influence –youth and children-media power-socio cultural and political consequences mass mediated culture-consumerist culture-Globalization-new media –prospects and challenges-Environmental ethics

Unit V(2 hours): **Values and Ethics** Personal values –family values-social values-cultural values-professional values-and overall ethics-duties and responsibilities

Project: 10 hours

References

1. Sharma, B. K. (2010), 'Human Rights Covenants and Indian Law', PHI Learning Pvt. Ltd.
2. Law Commission of India, (1971), 'Indian Penal code', (http://lawcommissionofindia.nic.in/1-50/report42.pdf), accessed on February 14, 2018.
3. Srivastava, S. S. (2017), 'Central Law Agency's Indian Penal Code along with General Principles (IPC)', Central Law Agency.
4. 'Gandhiji on Communal Harmony', (2003), Mani Bhavan Gandhi Sangrahalaya', Mumbai.
5. 'Social Impact of Drug Abuse', UNDCP, ((https://www.unodc.org/pdf/technical_series_1995-03-01_1.pdf, accessed on February 14, 2018).
6. Bryfonski, D. (2012), 'The Global Impact of Social Media', Green Heaven Publications.
7. Schmidtz, D. &Willott, E. (2012), 'Environmental Ethics: What Really Matters, What Really Works', Oxford University Press.
8. Ranganathanda, S. (1987), 'Eternal Values for a Changing Society: Education for human excellence', BharatiyaVidyaBhavan.
9. Rokeach, M. (1979), 'Understanding human values: Individual and Societal', The New Free Press.

ZZ1095D NSS

L	T	P	C
0	0	3	1

Course Outcomes

CO1: Acquire awareness in social and environmental issues thereby improving social consciousness and commitment towards the community.

CO2: Participate in socially relevant activities that are aimed at betterment of the campus and the society, thereby instilling a helpful attitude

CO3: Develop a positive attitude towards dignity of labour, self-help and the need for combining physical work with intellectual pursuits.

CO4: Improve inter-personal skills and contribute to nation building by serving the local community, thereby promoting a healthy and positive attitude towards life.

NSS activities have been divided in two major groups. These are Regular NSS Activities and Special Camping programme.

(a) Regular NSS Activity: NSS volunteers undertake various activities in adopted villages and slums for community service. The NSS units organise the regular activities as detailed below:

i) Orientation of NSS volunteers: To get the NSS volunteers acquainted with the basics of NSS programmes, for their orientation through lectures, discussions, field visits, audio-visuals etc.
ii) Campus Work: The NSS volunteers may be involved in the projects undertaken for the benefit of the institution and students concerned. Such projects cover maintenance of public properties, tree plantation, waste management and Swach Bharat activities, conservation of water and energy sources, social audits, awareness programmes on drug-abuse, AIDS, population education, and other projects
iii) Community service will be in adopted villages/urban slums independently or in collaboration with others in this field.
iv) Institutional work: The students may be placed with selected voluntary organisations working for the welfare of women, children, aged and disabled outside the campus.
v) Rural Project: The rural projects generally include the working of NSS volunteers in adopted villages for e-governance and digital literacy, watershed management and wasteland development, rainwater harvesting, agricultural operations, health, nutrition, hygiene, sanitation, mother and child care, gender equality sensitization programmes, family life education, gender justice, development of rural cooperatives, savings drives, construction of rural roads, campaign against social evils etc.
vi) Urban Projects: In addition to rural projects other include adult education, welfare of slum dwellers, work in hospitals, orphanages, destitute home, environment enrichment, population education, drug, AIDS awareness, and income generation,
vii) National Days and Celebrations: The National Service Scheme programmes also include the celebration of National days. The purpose of such a provision is to celebrate such occasions in a befitting manner,
viii) Blood Donation Activities,
ix) Campus farming activities,
x) Activities for social inclusion such as organizing programmes for differently – abled children.

Students shall volunteer and contribute to the activities of the National Service Scheme for a minimum duration of 45 hours for the award of credit.

b) Special Camping Programme: Under this, camps of 7 days' duration are organised during vacations with some specific projects by involving local communities. 50% NSS volunteers are expected to participate in these camps.