SCHEME & SYLLABUS

OF TEACHING & EVALUATION FOR

III & IV SEMESTERS

B.E. CHEMICAL ENGINEERING

2025-2026

[for 2024 admitted batch, 160 credit course, NEP 2.0]

SIDDAGANGA INSTITUTE OF TECHNOLOGY, TUMAKURU

(An autonomous institution affiliated to VTU, Belagavi, Approved by AICTE, New Delhi, Accredited by NAAC with 'A' grade & ISO 9001:2015 Certified)

B.E. in Chemical Engineering, NEP – 2, (160 credits Program)

SCHEME OF TEACHING AND EXAMINATION (2024 Admitted Batch) (w.e.f 2025-26)

Sl. No.	Course and Course Code		Course Title	Teaching / Paper setting Dept.	Teaching hrs/week				Examination				Credits
					Lecture	Tutorial	Practical/ Drawing	Self-Study Component	Duration in hrs.	CIE Marks	SEE Marks	Total Marks	
					L	T	P	S					
III Semester													
1.	BSC	S3MAT1	Statistics and Probability	Maths	3	0	0	-	3	50	50	100	3
2.	IPCC	S3CHI01	Momentum Transfer	ChE	2	2	2	-	3	50	50	100	4
3.	IPCC	S3CHI02	Technical Chemistry	Chem	3	0	2	-	3	50	50	100	4
4.	PCC	S3CH01	Process Calculations	ChE	3	0	0	-	3	50	50	100	3
5.	PCCL	S3CHL01	Computer Aided Engineering Drawing	ChE	0	0	2	-	3	50	50	100	1
6.	ESC	S3ESC1X	ESC / ETC	ChE	3	0	0	-	3	50	50	100	3
7.	AEC	S3AEC0X	Ability Enhancement Course	ChE	1	0	0	-	3	50	50	100	1
8.	UHV	SHS01	Social Connect and Responsibility (Board: ME)	ChE	0	0	2	-	3	100	-	100	1
9.	NCMC	SMC01	National Service Scheme (NSS)	NSS	0	0	2	-	-	100	-	100	0
		SMC02	Physical Education (Sports and Athletics)	PED									
		SMC03	Yoga and Pranayama	PED									
		SMC04	National Cadet Corps (NCC)	NCC									
			Total		**15**	**2**	**10**	**-**	**27**	**550**	**350**	**900**	**20**
		AAP	AICTE Activity Points	40 hours community service to be documented and produced for the exam									

Note: **IPCC**: Integrated Professional Core Course, **PCC**: Professional Core Course, **PCCL**: Professional Core Course Laboratory, **BSC**: Basic Science Course, **ESC**: Engineering Science Course, **ETC**: Emerging Technology Course, **AEC**: Ability Enhancement Course, **NCMC**: Non-credit Mandatory Course, **L**: Lecture, **T**: Tutorial, **P**: Practical/ Drawing, **S**: Self-Study Component, **CIE**: Continuous Internal Evaluation, **SEE**: Semester End Examination.

Engineering Science Course / Emerging Technology Course (Offered by the Department)			
S3ESC11	Material Science and Engineering	S3ESC12	Introduction to Polymer Science and Technology
S3ESC13	Introduction to Chemicals from Biomass	S3ESC14	Carbon Sequestration Technology
Ability Enhancement Course (Offered by the Department)			
S3AEC01	Basic Laboratory Practices and Data Analysis	S3AEC02	Professional Scientific Communication
S3AEC03	Introduction to Process Technology	S3AEC04	Life Cycle Assessment

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Sl. No.	Course and Course Code		Course Title	Teaching / Paper setting Dept.	Teaching hrs/week				Examination				Credits
					Lecture	Tutorial	Practical/ Drawing	Self-Study Component	Duration in hrs.	CIE Marks	SEE Marks	Total Marks	
					L	T	P	S					
IV Semester													
1.	PCC	S4CH01	Mass Transfer - I	ChE	2	2	0	-	3	50	50	100	3
2.	IPCC	S4CHI01	Process Heat Transfer	ChE	3	0	2	-	3	50	50	100	4
3.	IPCC	S4CHI02	Mechanical Operations	ChE	3	0	2	-	3	50	50	100	4
4.	PCCL	S4CHL01	Process Flow Diagram Laboratory	ChE	0	0	2	-	3	50	50	100	1
5.	ESC	S4ESC2X	ESC / ETC	ChE	3	0	0	-	3	50	50	100	3
6.	AEC	S4AEC0X	Ability Enhancement Course	ChE	1	0	0	-	3	50	50	100	1
7.	BSC	S4CCA01	Biology for Engineers (Board: BT)	BT, ChE	3	0	0	-	3	50	50	100	3
8.	UHV	SHS02	Universal Human Values (Board: IEM)	ChE	1	0	0	-	3	50	50	100	1
9.	NCMC	SMC01	National Service Scheme (NSS)	NSS	0	0	2	-	-	100	-	100	0
		SMC02	Physical Education (Sports and Athletics)	PED									
		SMC03	Yoga and Pranayama	PED									
		SMC04	National Cadet Corps (NCC)	NCC									
			Total		**16**	**2**	**8**	**0**	**24**	**500**	**400**	**900**	**20**
		AAP	AICTE Activity Points	40 hours community service to be documented and produced for the exam									

Note: **IPCC**: Integrated Professional Core Course, **PCC**: Professional Core Course, **PCCL**: Professional Core Course Laboratory, **BSC**: Basic Science Course, **ESC**: Engineering Science Course, **ETC**: Emerging Technology Course, **AEC**: Ability Enhancement Course, **NCMC**: Non-credit Mandatory Course, **L**: Lecture, **T**: Tutorial, **P**: Practical/ Drawing, **S**: Self-Study Component, **CIE**: Continuous Internal Evaluation, **SEE**: Semester End Examination.

Engineering Science Course / Emerging Technology Course (Offered by the Department)			
S4ESC21	Chemical Engineering Thermodynamics	S4ESC22	Industrial Safety Engineering
S4ESC23	Data Analytics	S4ESC24	Pilot Plant and Scale-up Methods
Ability Enhancement Course (Offered by the Department)			
S4AEC01	Material Selection for Mechanical Design	S4AEC02	Water and Wastewater Characterization
S4AEC03	Understanding Equipment Data Sheet	S4AEC04	Data Analytics with Excel

III Semester

STATISTICS AND PROBABILITY
(CSE, ISE, AI&DS. AIML, CIVIL, CHEM)

Contact Hours/ Week	3+0+0 (L+T+P)	Credits	3.0
Total Lecture Hours	39	CIE Marks	50
Sub. Code	S3MAT1	SEE Marks	50

Prerequisites: Engineering Mathematics-I & II

Course objectives: This course will enable students to:	
1	Develop and conduct appropriate experimentation, analyze and interpret data and use engineering judgment to draw conclusion.
2	Understand the basic concepts and applications of probability in engineering.
3	Learn the random variable, random process and how to model the random processes in engineering.
4	Understand the multiple random variables and stochastic process.
5	Investigate the variability in sample statistics from sample to sample, measure of central tendency & dispersion of sample statistics and pattern of variability of sample.

UNIT I
Statistics: Introduction, Curve Fitting: Straight line, reducible to Linear and Quadratic form-parabola. Definition of Correlation and regression lines, formula for correlation coefficient, regression lines with proof and angle between the regression lines, Rank correlation.
8 Hours

UNIT II
Probability: Basic terminology, Definition of probability, Probability and set notations, Types of events, Addition law of probability, conditional probability, multiplication law of probability, Baye's theorem.
8 Hours

UNIT III
Random Variable: Definition of Random Variable, Discrete Probability distribution, expectation, Variance, Binomial distribution, Poisson distribution. Continuous Probability distribution- expectation, Variance, Normal distribution and Exponential distributions.
8 Hours

UNIT IV
Joint Probability: Joint probability distribution, Discrete and independent random variables, Expectation, Covariance, Correlation coefficient. Probability vectors, stochastic matrices, fixed point matrices, Regular stochastic matrices. Markov chains, Higher transition-probabilities, stationary distribution of regular Markov chains and absorbing states
8 Hours

UNIT V
Sampling Distribution: Introduction, Objectives, sampling distribution, testing of hypothesis, level of significance, confidence limits, simple sampling of attributes, test of significance of large samples, comparison of large samples, sampling of variables, central limit theorem, confidence limits for unknown mean, test of significance for means of two large samples, Sampling of variables – small samples, Student's t-distribution
8 Hours

Text Books		
1	B. S. Grewal	Higher Engineering Mathematics, 43rd Edition, Khanna Publications, 2015. ISBN:978-81-7409-195-5.
2	B.V. Ramana	Higher Engineering Mathematics, Latest Edition, Tata-McGraw Hill, 2016. ISBN;0-07-053516-7.

Reference Books		
1	Erwin Kreyszig	Advanced Engineering Mathematics, 10e, Wiley Publications, 2015. ISBN: 978-81-7409-195-5.
2	C. Ray Wylie and Louis C. Barrett	Advanced Engineering Mathematics, 6e, Tata-McGraw Hill 2005.
3	Louis A. Pipes and Lawrence R. Harvill	Applied Mathematics for Engineers and Physicists, 3e, McGraw Hill, 2014.

Course Outcomes: Upon completion of this course, student will be able to:	
CO1	Apply least square method to fit a curve for the given data and evaluate the correlation coefficient and regression lines for the data. (L3)
CO2	Analyze the nature of the events and hence determine the appropriate probabilities of the events (L3)
CO3	Classify the random variables to determine the appropriate probability distributions and hence compute the associated probability. (L2)
CO4	Computes the joint probability and its parameters. Predicts the long run behavior of a Markov chain using transition matrix (L3).
CO5	Estimate the parameters of a population and sample in testing of hypothesis (L2).

	POs	1	2	3	4	5	6	7	8	9	10	11
COs	CO1	3										
	CO2	3										
	CO3	3										
	CO4	3	1									
	CO5	3	1									

MOMENTUM TRANSFER

Contact Hours/ Week	2+2+2 (L+T+P)	Credits	4.0
Total Lecture Hours	26	CIE Marks	50
Total Practical Hours	26	SEE Marks	50
Sub. Code	S3CHI01	Semester	3

Course objectives: This course will enable students to:	
1	Learn about concept of Unit Operations and apply the principles of dimensional analysis and similitude to obtain action to the solution of chemical engineering problems.
2	Acquire knowledge about properties and behavior of fluids under static, laminar and turbulent flow conditions.
3	Solve flow problems based on Continuity, Bernoulli's equations and pressure loss expression for flow through closed conduits.
4	Learn about transportation of fluids through pipes, construction, working and operations of pumps and principles of flow measuring devices and derive expressions and estimation of flow rate through venturi-meter, orifice-meter and Pitot tube.
5	Learn practical skills to conduct the performance of various piping devices, flow measuring device, centrifugal pumps, packed and fluidized beds through laboratory practice.

UNIT I
Introduction to concept of unit operations, Concept of Momentum Transfer Dimensional Analysis: Concept of dimensional homogeneity, Rayleigh's method and Buckingham π- method, Dimensional numbers and their Significance Introduction to principles of similitude and its significance in equipment design. Fluid and its properties: Fluid, its applications, properties of Fluids, Newtonian and Non-Newtonian Fluids, Effect of temperature on viscosity of fluids and their prediction.
6+8 Hrs

UNIT II
Fluid Statics: Concept of Pressure – Laws governing static fluids viz., Pascal's law, hydrostatic law and barometric equations Measurement of fluid Pressure: Principles and working of simple and differential type of manometer, principle and working of pressure gauge, and pressure transducer. Flow Behavior of fluids: Concept of Average, velocity, mass velocity, Types of flow in a closed conduit, Significance of Reynolds number. Laws governing Flow: Continuity equation, Euler's, Bernoulli's equation, Modification of Bernoulli's equation for real fluids. Significance of Navier-Stoke's equation. Flow of compressible fluids: Concept of Mach number and its application.
8+6 Hrs

UNIT III
Flow of incompressible fluids in Conduit (Laminar): Flow behaviour, Shear and Velocity Distribution for laminar flow through circular conduit, Derivation of Hagen-Poisullie's equation and application of Darcy Wesibach Equation. Characteristics of Turbulent flow – Averge velocity and estimation of velocity by 1/7th rule. Concept of friction: Friction factor, Moody's diagram, Types of friction, Correlation for estimation of friction factors for laminar and turbulent flow. Boundary Layer flow: Concept Boundary layer, Regimes, Boundary layer flow over a flat plate, entry length region and its significance for a circular conduit.
6+6 Hrs

UNIT IV
Transportation of Fluids: Pipes, Fittings and Valves, and their applications, significance of codes in design of piping systems, minor losses prediction methods Devices for transportation: Pumps, Classification of pumps Construction and working of Centrifugal, Reciprocating, and Gear type of pumps. Operation of pumps: Characteristic curves of centrifugal pumps – Concept of NPSH, Water hammering, Cavitation and Priming.
5+3 Hrs

UNIT V
Flow measurement: Classification of Devices, Principles, Construction and working venturi-meter, orifice-meter and pitot tube, principle, construction working of Rotameter, Principle of V-Notch Time to empty tank, principle, Construction and working of Magnetic flow meter and Coriolis flow meter.
3+2 Hrs

Text Books		
1	Cengel Y. A., and Cimbala J. A	Fluid Mechanics–Fundamentals and Applications, Mc Graw Hill, 2e, 2013,ISBN: 0-07-247236-7

2	Pati, S	Text Book of Fluid Mechanics and Hydraulic Machines, Mc Graw Hill, 1e, 2017, ISBN: 978-1259006234
3	Fox and McDonald	Introduction to Fluid Mechanics, WileyIndia Pvt Ltd, 10e, ISBN: 978-354641077

Reference Books		
1	Coulson J R and Richardson J F	Chemical Engineering Vol. I, Asian Books, New Delhi, 6e, 2006, ISBN:978-81847368
2	Badger W I and Banchero J T	Introduction to Chemical Engineering, Tata McGraw Hill, New Delhi, 1e, 2017, ISBN: 978-0074630501
3	James Wilkes	Fluid Mechanics for Chemical Engineers: with Microfluidics, CFD, and COMSOL Multiphysics 5, Pearson; 3e, 2017, ISBN:978-0134712826

MOMENTUM TRANSFER LABORATORY

Experiments (2 Hours/week)	
1	Study the variation of friction factor with Reynolds's number and to plot the universal resistance graph for flow through circular conduits.
2	Calibrate the given Orifice meter and to find out its coefficient discharge.
3	Study the flow distribution in a pipe and estimate the ratio of average velocity to maximum velocity at the centre of pipe for different flow rate using a pitot tube.
4	Calibrate the given venturimeter and to find out its coefficient discharge.
5	Determine the notch constants for a given V notch and find its Coefficient of discharge.
6	Study the characteristics of the centrifugal pump at constant Speed.
7	Determine the loss coefficient for pipe fittings.
8	Compare the pressure drop in a helical coil with that in a straight pipe of same length, inside diameter and surface roughness.
9	Verify the relationship between the velocity of the fluid and pressure drop per unit length of packing and to verify Ergun's equation.
10	Determine the coefficient of discharge of Rotameter.
11	Find the hydraulic Coefficient of orifice, Coefficient of contraction and Coefficient of velocity.

Course Outcomes: Upon completion of this course, student will be able to:	
CO1	Demonstrate about concept of Unit Operations and apply the principles of dimensional analysis and similitude to obtain action to the solution of chemical engineering problems.
CO2	Illustrate about properties and behavior of fluids under static, laminar and

	turbulent flow conditions.
CO3	Solve flow problems based on Continuity, Bernoulli's equations and pressure loss expression for flow through closed conduits.
CO4	Demonstrate knowledge about transportation of fluids through pipes, construction, working and operations of pumps and principles of flow measuring devices and derive expressions and estimation of flow rate through venturi-meter, orifice-meter and Pitot tube.
CO5	Exhibit practical skills to carry out studies on performance of various piping devices, flow measuring device, centrifugal pumps, packed and fluidized beds through laboratory practice.

	POs											PSOs			
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4
CO1	3	3											3		
CO2	3	3											3		
CO3	3	3											3		
CO4	3	2											2		
CO5	3	3											2		

TECHNICAL CHEMISTRY

Contact Hours/Week	3+0+2 (L+T+P)	Credits	4.0
Total Lecture Hours	39	CIE Marks	50
Total Practical Hours	26	SEE Marks	50
Sub. Code	S3CHI02	Semester	3

Course objectives: This course will enable students to:	
1	Introduce to the principles of electronic spectroscopy, infrared spectroscopy and NMR spectroscopy techniques and instruments, UV – Visible spectra, FTIR spectra and its interpretation, for identification of molecules
2	Learn about different kinds of reactive intermediates, attacking reagents and various Electronic displacement effects on organic reactions
3	Acquaint with principles of chromatographic separations and operation of modern chromatographic instrument, photochemistry, luminescence property of materials, and role of optical sensors identification of molecules
4	Acquire skills to for estimation of different organic compounds by standard methods
5	Acquire skills to determine using analytical instruments, amount of nitrates, transition temperature of salts, concentration of a given solute in a given mixture, and rate kinetics of a reaction.
6	Learn about analyzing the results obtained, validate and communicate the same through report writing

UNIT I
General Introduction to Spectroscopy: Introduction, Types of spectroscopy - atomic and molecular spectroscopy, nature and interaction of electromagnetic radiations with matter, energies corresponding to various kinds of radiations, spectral band width – definition and factors contributing spectral width, factors influencing positions and intensity of spectral lines. Electronic Spectroscopy: Principles of electronic spectroscopy - Types of electronic transitions in organic molecules. Chromophores and auxochromes. Bathochromic shift or Red shift, hypsochromic shift or blue shift. Hyperchromic effect and hypochromic effect. Effect of solvent and extent of conjugation on λmax and on the energies of n $-\pi^*$ and $\pi - \pi^*$ transitions. Instrumentation, qualitative and quantitative analysis.
8 Hours

UNIT II
Infrared Spectroscopy: Principles of IR spectroscopy. Requirements for IR absorption. Types of vibrations - Stretching vibrations and bending vibrations. Fundamental modes of vibrations for linear and non linear molecules. Characteristic group frequencies for infrared absorption of organic molecules. Factors affecting the group frequencies – coupled interactions (Fermi resonance, aldehyde) electronic effects (carbonyl compounds) and hydrogen bonding (alcohols, carboxylic acids). Numerical problems on vibrational frequencies. Instrumentation - FTIR instrument and its advantages. Sample handling techniques – Nujol mull and KBr pellet.
8 Hours

UNIT III
Nuclear Magnetic Resonance Spectroscopy: The nuclear spin, Larmor precession, the NMR isotopes, energy levels for a nucleus with spin quantum number I = ½ , 3/2 and 5/2, theory of population of nuclear spin levels, spin- spin and spin-lattice relaxation, chemical shift – definition, causes, measurement. TMS as a reference compound and its advantages, factors affecting chemical shift, shielding and deshielding mechanisms, spin – spin coupling, spin – spin splitting, intensity ratio of multiplet-Pascal's triangle method, chemical exchange, effect of deuteration, classification of spin systems (AX, AMX, AB, ABC), first order spectra, low and high resolution spectra, determination of peak areas, coupling constants-short and long range couplings, Instrumentation of NMR.
8 Hours

UNIT IV
Fundamentals of Organic Chemistry: i) Bond cleavage: Homolytic and heterolytic bond cleavage. Attacking reagents – electrophiles and nucleophiles. Reactive intermediates - carbocations, carbanions and free radicals, their types, structure, formation, and stability. ii) Nucleophilic aliphatic substitution reactions: Meaning of SN1 and SN2 reaction.

Mechanism of hydrolysis of alkyl halides of SN1 and SN2 reactions, SN2 versus SN1 reactions. Effect of nature of alkyl groups, leaving groups, nucleophiles and solvents on SN1 and SN2 mechanisms.

iii) Elimination reactions: Meaning of E1 and E2 reactions. Mechanism of dehydrohalogenation of alkyl halides of E1 and E2 reactions. E1 versus E2 mechanism.

iv) Nucleophilic and electrophilic aromatic substitution reactions: Electrophilic aromatic substitution reactions. Meaning and reactions of electrophilic aromatic substitution. Nitration, sulphonation, halogenation, Friedel-Craft alkyl and acylation reactions of benzene.

v) Nucleophilic addition and rearrangement reactions: Condensation Reactions: Reaction of Aldol and Claisen condensation. Rearrangement Reactions: Reaction of Reimer-Tiemann and Pinacol-pinacolone rearrangement.

8 Hours

UNIT V

Fundamentals of Quantum Mechanics: Introduction to Quantum Mechanics, Classical Mechanics and its limitations, blackbody radiation, photoelectric effect, Compton effect, Schrödinger equation (time-dependent and time-independent), Postulates of Quantum Mechanics: Operators, wave functions, Eigenvalue equations, expectation values, Applications to model systems: particle in a box, harmonic oscillator, hydrogen atom, rigid rotor. Approximation methods, perturbation theory, variational method, Chemical Bonding: Hydrogen molecular ion, linear combination of atomic orbitals (LCAO), molecular orbitals, valence bond theory, molecular orbital theory, modern density-functional theory (DFT), description of molecules: Valence bond treatment and stability of bonds, molecular orbital theory and its applications in simple systems, molecular orbital theory of polyatomic molecules, the concept of delocalization, conjugated systems, butadiene. Molecular orbitals of homonuclear and heteronuclear diatomic molecules. VSEPR. Molecular orbital and valence bond approaches to polyatomic molecules. Hybrid orbitals and Huckel theory.

8 Hours

Course Outcomes: Upon completion of this course, student will be able to:

CO1	Demonstrate knowledge about the principles of electronic spectroscopy, infrared spectroscopy and NMR spectroscopy techniques and instruments, UV-Visible spectra, FTIR spectra and its interpretation, for identification of molecules
CO2	Predict about different kinds of reactive intermediates, involved in a reaction
CO3	Identify the analyte present in the mixture by applying principles of chromatography, and optical properties of the material by photochemistry technique

CO4	Estimate organic compound present in a solution by adopting standard methods
CO5	Demonstrate skills to use analytical instruments, to estimate chemical and physical parameters of a solution/mixture
CO6	Exhibit skill to analyze obtained results, validate and submit a technical report

TECHNICAL CHEMISTRY LABORATORY

Experiments (2 Hours/week)	
1	Estimation of alcohol by acetylation.
2	Estimation of phenol by bromination.
3	Estimation of carboxylic acid by iodometric titration.
4	Estimation of esters by hydrolysis.
5	Colori-meter-Determination of nitrate in the given watersample using colorimeter.
6	Viscometry - Determination of percentage composition of binary mixture using Ostwald's viscometer.
7	Conductometry – Determination of HCl and CH3COOH in the given acid mixture using sodium hydroxide solution and potassium hydrogen phthalate crystals.
8	Partition coefficient-Determination of partition coefficient of iodine between water and Carbon tetrachloride.
9	Reaction Kinetics- Study of kinetics of the reaction between K2S2O8 and KI.
10	Determination of transition temperature of the given salt hydrate.
11	Determination of iron asferric oxide gravimetrically (after separating Barium) in the given Barium Ferrite ore solution.
12	Fourier transform infrared spectroscopy (FTIR) - Detection of functional groups in the given Sample (Demonstration of the experiment)
13	X-Ray Diffraction (XRD) technique for material characterization (Demonstration of the experiment).

Text Books:		
1	R.M. Silverstein and W.P. Webster	Spectrometric Identificationof organic compounds, Wiley & Sons, 1999
2	Morrison B.R. and Boyd	Organic Chemistry, L.L., 6th Edition, ELBS, New Delhi, 1999
3	Rajbir Singh	A Textbook of Chromatography, 2016, Mittal Publications
4	Colin F. Poole	The Essence of Chromatography, 2003, Elsevier publications.

Reference Books	
G.W. Ewing	Instrumental methods of Chemical Analysis, McGraw-Hill, India, 5e, 2013, ISBN: 978-1259097072
Holler, Skoog, Crouch	Principles of Instrumental Analysis, Cengage, 6e, 2014, ISBN: 978-8131525579
Chatwal Anand,	Instrumental Methods of Chemical Analysis, Himalaya Publishing House, 5e, 2014, ISBN: 978-9351420880

COs	POs										
	1	2	3	4	5	6	7	8	9	10	11
CO1		2									
CO2	1										
CO3	1										
CO4				4							
CO5			3								

PROCESS CALCULATIONS

Contact Hours/Week	3+0+0 (L+T+P)	Credits	3.0
Total Lecture Hours	39	CIE Marks	50
Sub. Code	S3CH01	SEE Marks	50

Course objectives: This course will enable students to:	
1	Introduce the principles and calculation techniques in chemical engineering
2	Acquaint students with material and energy balance calculations.
3	Teach basic calculation techniques in processes involving chemical reactions
4	Illustrate the significance of bypass, recycle, and purging operations in process engineering and introduce relevant calculations.
5	Introduce the concept of unsteady-state material and energy balance in process engineering and relevant calculations.

UNIT I
Units and dimensions: Fundamental and derived units; conversion of units and equations, dimensional homogeneity. Basic chemical calculations: Concepts of mole, mole fraction; compositions of mixtures of solids, liquids and gases; concepts of normality, molarity, molality, ppm
8 Hours

UNIT II
Material balance without reaction: General material balance equation for steady state operations. Typical steady state material balances in distillation, extraction, crystallization, drying, mixing and evaporation.
9 Hours

UNIT III
Material balance with reaction: Principles of Stoichiometry, concepts of limiting, excess reactants, fractional and percentage conversion, fractional yield and percentage yield, selectivity. Steady state material balance for inorganic, organic and biochemical reactions, Calculations involving burning of solid, liquid and gaseous fuels, excess air, Air-fuel ratio calculations.
9 Hours
UNIT IV
Bypass, recycle and purge: Material balance for processes (with and without reactions) involving bypass, recycle and purging. Unsteady state material balance: Solving unsteady-state material balance to obtain equations for system parameters as a function of time using differential equations & boundary conditions.
9 Hours
UNIT V
Energy balance: General steady state energy balance equation, Thermophysics; Thermochemistry and laws. Concepts of heat capacity, enthalpy, heat of formation, heat of reaction, heat of combustion and calorific values, heat of solution, heat of mixing, heat of crystallization. Determination of ΔH_F at standard and elevated temperatures, theoretical flame temperature and adiabatic flame temperature. **Unsteady state energy balance:** Solving unsteady-state material balance to obtain equations for system parameters as a function of time using differential equations & boundary conditions.
9 Hours

Textbooks:		
1	Narayanan, K.V., Lakshmikutty, B	Stoichiometry and Process Calculations, PHI Learning Pvt. Ltd., Connaught Circus, New Delhi, 2e, 2016, ISBN: 978-8120352896
2	Himmelblau, D.M., and Riggs, J.B	Basic Principles and Calculations in Chemical Engineering, PHI Learning Pvt. Ltd., Connaught Circus, New Delhi, 8e, ISBN: 978-81-325-4962-3

Reference Books:		
1	Felder, R.M., and Rousseau, R.W	Elementary Principles of Chemical Processes, Wiley India (P.) Ltd., New Delhi, 3e, year, ISBN:978-81-265-1582-0
2	B I Bhatt, S B Thokore	Stoichiometry, McGraw Hill, 5e, ISBN:978-0-07-068114-9

Course Outcomes: Upon completion of this course, student will be able to:	
CO1	Demonstrate the knowledge of calculations in chemistry, physics, and mathematics and apply them to solve basic chemical engineering unit operations and processes.
CO2	Analyze problems related to process calculations and provide conclusions using the first principles of gas laws, phase equilibria, material and energy balance.
CO3	Develop solutions to basic and complex process calculations problems
CO4	Communicate the solutions to process calculations problems effectively in both oral and written form
CO5	Demonstrate the ability of identify, analyze and solve process calculation problems individually and in a team

COMPUTER AIDED EQUIPMENT DRAWING

Contact Hours/ Week	0+0+2 (L+T+P)	Credits	1.0
Total Practical Hours	26	CIE Marks	50
Sub. Code	S3CHL01	SEE Marks	50

Course objectives: This course will enable students to:	
1	Learn the fundamental concepts of Engineering Graphics and its interface with computer.
2	Introduce to the conventions, symbols and rules followed in drawings and methods of representing the same.
3	Learn about representing sectional views and selection of reference plane for assembly and piping symbols.
4	Acquire skills to represent assembly and sub-assembly of various elements.
5	Prepare assembled drawings using the software tool.

PART A
Introduction and Proportionate Drawing, Introduction: Review of graphic interface of the software. Review of Basic sketching commands and navigational commands. Starting a new drawing sheet, sheet size. Naming a drawing. Drawing modules grid and snap. Proportionate Drawings: Important equipment symbols, piping symbol and pipe joints, proportionate drawings of some parts of equipment. proportionate drawings of some common equipment.
13 Hours
PART B
Assembly Drawings, Joints: Socket and Spigot joint, Cotter joint with sleeve, Stuffing box and Expansion joint (Any Two of the above). Valves: Stop valve, Gate valve, Rams Bottom safety valve, Non-return valve. (Anyone of the above).
13 Hours

Text Books		
1	K R Gopal Krishna	Machine Drawing, Subhas Stores, Bangalore, 9e, 1995,

2	Bhatt N.D.	Machine Drawing, Charotar Publishing House, Anand, 50e, 2014, ISBN: 978-9385039232

Reference Books		
1	Walas S.M	Chemical Process Equipment Butterworth Heinemann Pub, USA, 4e, 2012, ISBN: 978-0123868800

Course Outcomes: Upon completion of this course, student will be able to:	
CO1	Demonstrate knowledge about the engineering graphics and adoption of the same in Computer Aided Drawing (CAD) as tool for drawing.
CO2	Draw the precise engineering drawings and represent the same systematically adopting the standard conventions.
CO3	Develop views of simple elements and piping symbols using CAD tool.
CO4	Demonstrate practical skills to generate 3D models of the simple and elemental parts of the assembly.
CO5	Generate 3D model of assembly for easier Comprehension and effective communication.

	POs											PSOs			
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4
CO1	2				2							1			
CO2	1												2		
CO3			3									1			
CO4											3		2		
CO5												1			

MATERIAL SCIENCE AND ENGINEERING

Contact Hours/ Week	3+0+0 (L+T+P)	Credits	3.0
Total Lecture Hours	39+0+0	CIE Marks	50
Sub. Code	S3ESC11	SEE Marks	50

Course objectives: This course will enable students to:	
1	Introduce to the material engineering fundamentals, phase transformations and phase diagrams, material processing problems in nucleation and crystal growth through TTT and CCT curves.
2	Learn about types of deformation in materials, mechanism of deformation and different heat treatment methods.
3	Acquaint with the selection and the use of Engineering Materials.
4	Introduce to the field of Nanomaterials, processing principles and methods of synthesis.
5	Introduce to advanced Materials and Smart materials and their applications.

UNIT I
Phase rule, Single component systems (Phase diagram for H_2O), Binary phase diagrams (copper–nickel, copper–silver, copper–zinc), Lever rule, Typical phase diagrams for Iron – Carbon systems, Nucleation and growth, solidification, Allotropic transformation, Cooling curve for pure iron, Iron-carbon equilibrium diagram, Isothermal transformations (TTT Curves).
8 Hours

UNIT II
Deformation of Materials And Fracture: Elastic deformation, Plastic deformation, Creep, Visco-elastic deformation, Different types of fracture. Heat Treatment: Annealing, Normalizing, Hardening, Martempering, Austempering, Hardenability, Quenching, Tempering, Carburising, Cyaniding, Nitriding, Flame hardening.
8 Hours

UNIT III
Ferrous metals, Non-ferrous metals and alloys – Aluminum and its alloys, Copper and its alloys. Alloys for high temperature service, Ceramic materials, Mechanical, electrical and thermal properties of ceramic phase.
8 Hours

UNIT IV
Classification, synthesis, characterization [SEM, XRD, TEM] and application of Nano materials–Fullerenes, Buckyballs, carbon nano tubes, fullerites. Applications of Nano materials.
7 Hours

UNIT V
Composite materials, definition, Constituents classification, types of matrix materials and reinforcements, fundamentals of Particle-reinforced composites and Fibre-reinforced composites, advantages and applications of composites.
8 Hours

Textbooks:		
1	Raghavan V	Materials Science and Engineering-A First Course, Prentice Hall of India. New Delhi, 3e, 2015, ISBN:978-8120350922
2	Charles P Poole, Frank J Owens	Introduction to Nanotechnology, John Wile & Sons, 1e, 2007, ISBN:978-8126510993
Reference Books		
1	Van Vlack H.L.	Elements of Materials Science, Addison–Wesley Publishing Company, New York, 2e, 2002,

		ISBN:978-8131706008
2	Guazhong Cao	Nanostructures and Nanomaterials: Synthesis, Properties, and Applications, Imperial College Press, UK , 1e, 2011, ISBN: 978-9814324557.

Course Outcomes: Upon completion of this course, student will be able to:	
CO1	Apply the knowledge of materials engineering fundamentals, phase transformations, transformation curves, and different heat treatment methods to materials development.
CO2	Identify, formulate, and analyze materials processing problems in nucleation and crystal growth through TTT and CCT curves.
CO3	Select appropriate material for a given application.
CO4	Demonstrate the knowledge of nanomaterials processing, principles, and methods.
CO5	Illustrate about composite and advanced materials and their applications

	POs										PSOs			
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4
CO1	3											3	3		
CO2	3	2										2	2		
CO3	3											2	2		
CO4	3	2										3	2		
CO5	3											3	2		

INTRODUCTION TO POLYMER SCIENCE AND TECHNOLOGY

Contact Hours/Week	3+0+0 (L+T+P)	Credits	3.0
Total Lecture Hours	39	CIE Marks	50
Sub. Code	S3ESC12	SEE Marks	50

Course objectives: This course will enable students to	
1	Introduce to the field of polymers, structure and classification of polymers.
2	Acquaint with polymer synthesis methods and characterization techniques used for polymers.
3	Learn about selection criteria for appropriate material for the engineering applications.
4	Introduce to the advanced technology applications of polymers.
5	Introduce to the different polymer degradation and the management of plastics in environment.

UNIT I
Introduction and classification: Classification of polymers: Thermoplastics and thermosets, classification based on mechanism of polymerization and polymer structure. Polymer structure: Copolymers, Tacticity, Geometric Isomerism, and Nomenclature. Molecular weight: Molecular weight distribution and molecular weight averages. Application of polymers.
8 Hours

UNIT II
Synthesis of polymers: Step growth polymerization: Molecular-weight in step-growth polymerization, Step growth polymerization kinetics. Chain-Growthpolymerization: Free-Radical Polymerization and Copolymerization, Ionic Polymerization and Copolymerization, Coordination Polymerization, Controlled Radical Polymerizations. Chemical structured determination : Vibrational Spectroscopy, Nuclear Magnetic Resonance Spectroscopy
8 Hours

UNIT III
Conformation, Solution, and Molecular Weight: Polymer Conformationand Chain Dimensions. Polymer solutions: The Flory–Huggins Theory, Equation-of-State, Theories, Phase equilibria, Determination of interaction parameter, and prediction of solubilities. Measurement of Molecular Weight: Osmometry, Light- Scattering Methods, Intrinsic Viscosity Measurements, and Gel-Permeation Chromatography.
8 Hours

UNIT IV
Polymer for advanced technologies: Membrane Science and Technology: Barrier Polymers, Membrane Separations, Mechanisms of Transport, Membrane Preparation. Biomedical Engineering and Drug Delivery: Controlled Drug Delivery, Gene therapy, and Antimicrobial Polymers. Applications in Electronics and Energy: Electrically Conductive Polymers, Polymeric Batteries, and Organic Photovoltaic Polymers. Photonic Polymers: Nonlinear Optical Polymers and Light- Emitting Diodes. Sensor applications.
8 Hours

UNIT V
Polymer degradation and environment: Polymer Degradation and Stability: Thermal Degradation, Mechano degradation, Oxidative and UV Stability, Chemical and Hydrolytic Stability. Management of Plastics in the Environment: Recycling, Incineration, and Biodegradation.
7 Hours

Text Books		
1	Fried J R	Polymer Science and Technology, Prentice Hall of India Pvt. Ltd., New Delhi, 2e, 2005, ISBN:978-8129709097.
2	Premamoy Ghosh	Polymer Science and Technology, 3rd Edition, Tata Mc. Graw-Hill Publishing Company, New Delhi, 2010, ISBN:978-00707070747.
3	R. Sinha	Outlines of Polymer Technology: processing of Polymers, Prentice Hall of India Pvt. Ltd., New Delhi, 2004, ISBN:978-8120321885

Reference Books		
1	F.W. Bill Meyer	Text book of polymer science, John Wiley & sons, 3e, 1984, ISBN:978-0471828341

Course Outcomes: Upon completion of this course, student will be able to	
CO1	Illustrate the structure and classification of polymers.
CO2	Choose appropriate polymer synthesis method and characterization techniques
CO3	Identify the appropriate material for the engineering applications.
CO4	Suggest suitable technique for the polymer degradation

	POs											PSOs			
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4
CO1	3											3			
CO2	3											2			
CO3	3											2			
CO4	3	2										3			
CO5	3					2						3			

INTRODUCTION TO CHEMICALS FROM BIOMASS

Contact Hours/Week	3+0+0 (L+T+P)	Credits	3.0
Total Lecture Hours	39	CIE Marks	50
Sub. Code	S3ESC13	SEE Marks	50

Course objectives: This course will enable students to:	
1	Introduce to biomass and its value addition
2	Learn about various treatment methods for value addition of biomass
3	Acquaint with methods of obtaining platform molecules
4	Learn about methods of obtaining chemicals form biomass
5	Learn about biomass-based materials and its derivatives

UNIT I
Introduction to Bio refinery concept: Renewable resources, Definition, types of bio refinery, challenges and opportunities. Challenges of waste: Waste Policy and Waste Valorisation, Food supply chain waste opportunity. Biomass: Lignocellulosic biomass, food supply chain waste. Mango waste: case study
8 Hours

UNIT II
Treatment of Biomass: Biomass Pre-treatment: Mechanical, physical, chemical, microwave assisted hydrothermal, biological methods. Thermochemical Treatment: Direct liquefaction, combustion, gasification, pyrolysis Torreaction and biological Processing.
8 Hours

UNIT III
Platform Molecules: Fossil derived base chemicals, Platform molecule, and its sources, Technologies for synthesis of platform molecules, Changing scenario of bio vs. fossil-derived chemicals, synthesis of gas platform and triglyceride platform
8 Hours

UNIT IV
Monomers, Polymers from Biomass: Polymers from Vegetable Oils: Isolation, Thermosets of vegetable oils, polyurethanes from vegetable oils, polyesters, polyamides. Terpenes: Production, Polymerization and Copolymerization, Polymerisation of Non-Pinene terpeness, Terpenoids, Production of PLA, its properties and applications
8 Hours

UNIT V
Bio-based Materials: Wood and Natural Fibers, Isolation and Modification of biopolymers as biomaterials: cellulose and its derivatives, chitin and chitosan and proteins
7 Hours

Text Books		
1	Clark J., and Deswarte F., Ed	Introduction to Chemicals from Biomass, John Wiley & Sons Ltd., UK, 2e, 2015, ISBN:978-1-118-71448-5

Reference Books		
1	Klass, D. L	Biomass for Renewable energy, fuels and chemicals, Academic Press UK, 1e, 1998, ISBN: 978-0-12-410950-6
2	Hornung A	Transformation of Biomass- Theory and Practice, John Wiley &

		Sons Ltd., UK, 1e, 2014, ISBN: 978-1-119-97327-0
3	Brown R. C., Ed.,	Thermo chemical Processing of Biomass, John Wiley & Sons Ltd., UK, 1e, 2011, ISBN:978-0-470-72111-7

Course Outcomes: Upon completion of this course, student will be able to:	
CO1	Demonstrate the knowledge of biomass as a resource to derive various chemical product
CO2	Choose suitable treatment methods for deriving products from biomass
CO3	Identify technology for obtaining platform molecule
CO4	Choose an efficient methods for deriving various chemicals starting from biomass
CO5	Illustrate the role of biomass in developing new products chemicals for day to day application

	POs											PSOs			
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4
CO1	1	2					3					2			
CO2	1	2					3					2			
CO3	1	2					3					2			
CO4	1	2					3					2			
CO5	1	2					3					2			

CARBON SEQUESTRATION TECHNOLOGY

Contact Hours/Week	3+0+0 (L+T+P)	Credits	3.0
Total Lecture Hours	39	CIE Marks	50
Sub. Code	S3ESC14	SEE Marks	50

Course objectives: This course will enable students to	
1	Introduce to the carbon cycle, capture and storage.
2	Acquaint with physical & chemical absorption of carbon dioxide from industrial processes.
3	Learn about adsorption capture system and different types of adsorption technology for carbon capture.
4	Acquaint with the principle and operation of cryogenic process for carbon absorption.
5	Learn about geological and ocean storage methods.

UNIT I
Introduction: The carbon cycle, mitigating growth of the atmospheric carbon inventory. The process of technology innovation, overview of carbon capture and storage.
8 Hours

UNIT II
Adsorption Capture System: Chemical and physical fundamentals, adsorption application in post combustion capture, adsorption technology R & D status. Carbon Capture from industrial processes: cement production, steel production, oil refining, natural gas processing.
8 Hours

UNIT III
Adsorption Capture System: Physical and Chemical fundamentals, adsorption process applications, adsorption technology RD & D status.
7 Hours

UNIT IV
Membrane separation system: Physical and Chemical Fundamentals, Membrane configuration and preparation and module construction, Membrane technology RD & D status, Membrane application in pre- combustion capture, Membrane application in oxyfuel combustion and post combustion CO_2 separation.
8 Hours

UNIT V
Geological Storage: Introduction, Geological and engineering fundamentals, Enhanced oil recovery, saline aquifer storage, other geological storage options **Ocean Storage:** Introduction, physical chemical and biological fundamentals, direct CO2 injection, chemical sequestration and biological sequestration.
7 Hours

Text Books		
1	Stephan A Rarkely	Carbon Capture and Storage, Butterworth Heinmenn, 1e, 2010, ISBN:978-1-85617-636-1

Reference Books		
1	Rao Y S ., Eds	Carbon Capture & Storage, ASCE Publications, 1e, 1367-8, 2015, ISBN:978-0-7844
2	Berend et	Introduction to capture and sequestration, Imperial College Press, 1e, 2014, ISBN: 978-1-78326-827

Course Outcomes: Upon completion of this course, student will be able to:	
CO1	Illustrate the carbon cycle and significance of carbon capture and storage.
CO2	Demonstrate knowledge about the principles beyond the physical and chemical absorption of carbon from industrial processes.
CO3	Suggest suitable adsorbent and type of adsorption capture system for carbon capture.

CO4	Illustrate the working principle and benefits of cryogenic process.
CO5	Differentiate geological and ocean storage methods along with their merits and demerits

	POs											PSOs			
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4
CO1	1	2					3					2			
CO2	1	2					3					2			
CO3	1	2					3					2			
CO4	1	2					3					2			
CO5	1	2					3					2			

BASIC LABORATORY PRACTICES AND DATA ANALYSIS

Contact Hours/Week	0+0+2 (L+T+P)	Credits	1.0
Total Practical Hours	15+0+0	CIE Marks	50
Sub. Code	S3AEC01	SEE Marks	50

Course objectives: This course will enable students to:	
1	Introduce the importance and basics of data, errors in data and data analysis.
2	Acquaint students with various mathematical procedures for data analysis and engineering calculations.
3	Train and allow practice of MS Excel, MS Power point and MS Word for engineering calculations and reporting.
4	Illustrate and allow practice of basic laboratory skills, laboratory safety and good laboratory practices.

Experiments and Practical Exercises on Errors in data and calculations:	
1	Measurement of mass, pH, volume (2 h)
2	Measurement of density, specific gravity (1 h)
3	Measurement of viscosity (1 h)
4	Measurement of absorbance, concentration (using standard curve, 3 h)
5	Preparation of solutions of varying normality/molarity and buffers (3 h)
6	MS Excel introduction and practice (2 h)
7	Presentation of experimental data using MS Excel (2 h)

Experiments and Practical Exercises on Data Analysis:	
1	Curve fitting using linear regression analysis (analytical) (2 h)
2	Curve fitting with non-linear regression analysis (analytical) (2 h)
3	Curve fitting with linear regression analysis using MS Excel (2 h)
4	Curve fitting with non-linear regression analysis using MS Excel (2 h)

Experiments and Practical Exercises on Mathematical Procedures:	
1	Practice problems on trial-and-error, graphical integration (2 h)
2	Practice problems on, log-log, semi-log, triangular plots (2 h)

Text Books		
1	Pauline M. Doran	Bioprocess Engineering Principles, 2e, 2013, ISBN: 978-0-12-220851-5
2	National Research Council	Prudent Practices in the Laboratory: Handling and Management of Chemical Hazards, National Academies Press, Washington, DC 2011, ISBN: 978- 0-309-13864-2

Course Outcomes: Upon completion of this course, student will be able to:	
CO1	Classify basic science and engineering data and related errors and apply them to solve basic engineering calculations and problems.
CO2	Analyze basic science and engineering data and provide conclusions.
CO3	Apply computational techniques (MS Excel) for data analysis and to solve complex mathematical functions.
CO4	Communicate basic science and engineering data using MS Office in oral and written forms.
CO5	Demonstrate basic chemical laboratory skills with an emphasis on safety and good laboratory practices.

	POs											PSOs			
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4
CO1	2	3			2							2			
CO2	2	3			2							2			
CO3	2	3			2							2			
CO4	2	3			2							2			
CO5	2	3			2							2			

PROFESSIONAL SCIENTIFIC COMMUNICATION

Contact Hours/Week	1+0+0 (L+T+P)	Credits	1.0
Total Lecture Hours	15+0+0	CIE Marks	50
Sub. Code	S3AEC02	SEE Marks	50

Course objectives: This course will enable students to:	
1	The concepts of creativity, reasoning, hypothesis and experimentation
2	Types of reports: original research articles, reviews, project reports, etc
3	Reading, written and oral scientific communication
4	The importance of ethics in scientific communication

UNIT I
Introduction to Professional Scientific Communication, Discussion of creativity, research ideas and where to find them, Inductive reasoning versus deductive reasoning
3 Hours

UNIT II
Hypothesis, reasoning and testing the hypothesis, Peer review process
3 Hours

UNIT III
Structure of a Research article, Title, abstract, methods, results, and discussion
3 Hours

UNIT IV
Structure of a Research article contd., Schematic diagrams, figures, tables and flow charts–rationale and usage
3 Hours

UNIT V
Ethics in research. Different forms of writing: scientific report, proposal, and reviews, Presentations-thumb rules and good practice
3 Hours

Text Books		
1	L Bowater, K Yeoman	Science Communication: A Practical Guide for Scientists, Wiley-Blackwell, 2013, ISBN:9781299181267

Reference Books		
1	M Brake, E Weitkamp	Introducing Science Communication: A Practical Guide, Red Globe Press, 2009, ISBN:9780230573857
2	W B Krantz	Presenting an Effective and Dynamic Technical Paper, Academic Press, 2016, ISBN:9780128054185

Course Outcomes: Upon completion of this course, student will be able to	
CO1	Demonstrate basic understanding of concepts and methodology in scientific research
CO2	Propose proper methodology for conducting a research project
CO3	Demonstrate the knowledge of data collection, analysis and reporting
CO4	Demonstrate the significance of ethics in scientific research
CO5	Demonstrate the ability to communicate orally and in written forms

	POs											PSOs			
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4
CO1	2											2			
CO2	2											2			
CO3	2	2										2			
CO4						2	2					2			
CO5									3			3			

INTRODUCTION TO PROCESS TECHNOLOGY

Contact Hours/Week	1+0+0 (L+T+P)	Credits	1.0
Total Lecture Hours	15	CIE Marks	50
Sub. Code	S3AEC03	SEE Marks	50

Course objectives: This course will enable students to:	
1	Introduce to the nature and application of process drawing with their significance in the process industries.
2	Introduce to the functions and uses of various types of pipes and valves and maintenance of them in industries.
3	Learn about the types and functions of various types of vessels, types of cooling towers with their significance, safety practice procedures in process industries.
4	Learn about boilers, components of a boiler, types of boiler and their role and maintenance in process industries.
5	Introduce to various process auxiliaries, their function and their need in industry

UNIT I

Process Drawings: Purpose of Process drawings, Common Components and Process Drawings Information: Symbols, Legend, Title Block, Application Block. Types of Process Drawing and their uses: Block flow diagrams (BFDS), Process Flow Diagrams, Piping and Instrumentation Diagrams (P&IDS), Engineering Flow Diagrams, Plot Plan Diagrams (PPDS), Utility Flow Diagram, Electrical Diagrams, Isometric Drawings, Other Drawings.

3 Hours

UNIT II

Piping and Valves: Purpose and Function of Piping and Valves, Construction Materials in Piping and Valves, Connecting Methods for Piping and Valves: Threaded, Flanges, Welds, Bends; Fitting types, Valve Types: Ball Valve, Plug valve, Butterfly valve, Check valve, Diaphragm Valve, Gate Valve, Globe Valve, Relief and Safety Valves, Valve actuators, Operational hazards, Monitoring and

Maintenance Activities; Piping and Valve symbols.
3 Hours

UNIT III
Vessels: Purpose of Vessels, Types of Tanks, Common Components of Vessels, Containment Walls, Dikes, Firewalls, Reactors: Purpose and Types; Operational Hazards, Monitoring and maintenance activities, Symbols for vessel and Reactors. Cooling Towers: Purpose of Cooling Towers, Types of Cooling Towers, Component Parts of an Open Cooling Tower, Principles of Operation of Open Circuit Cooling Towers, Factors that affect cooling tower performance, Cooling Tower Applications, Operational Hazards, Monitoring and maintenance activities, Cooling Tower Symbols.
3 Hours

UNIT IV
Boilers- Introduction, Purpose of Boilers, Parts of a Boiler, How a Boiler Works, Fuels used in Boilers, Water and Fire tube boilers, Operational hazards, Monitoring and Maintenance activities, Boiler symbols.
3 Hours

UNIT V
Process Auxiliaries: Types of Process auxiliaries, Flare Systems and associated equipment, Refrigeration Systems and associated components, Components of Mechanical Refrigeration System, Lubrication Systems and Associated Components, Hot Oil Systems and Associated Components. Other common auxiliary systems: Amine, Fluidized Bed Systems, Nitrogen Header, Operational Hazards, Monitoring and Maintenance Activities.
3 Hours

Text Books		
1	Martha McKinlley, Ed.	Introduction to Process Technology, Pearson Education Inc., USA, 2018, 2e, ISBN:978-0-13-480824-6

Reference Books		
1	Charles E. Thomas	Introduction to Process Technology, 3e, Cengage Learning, USA, 2010, ISBN:13-978-1-4354-5425-5.
2	Charles E. Thomas	Process Technology and Equipment Systems, 4e, Cengage Learning, USA, 2015, ISBN:978-1-285-44458-1

Course Outcomes: Upon completion of this course, student will be able to:	
CO1	Identify the various types of process diagrams and identify the various components through the symbols denoted on them.

CO2	Identity different types of pipes and valves by their symbols and regular maintenance schedules adopted in work place.
CO3	Identify different types of vessels and cooling towers and avoid the hazards associated with them in work place.
CO4	Describe the various components of boiler their operation and maintenance.
CO5	Describe about the various process auxiliaries and exhibit awareness about operational hazards and maintenance practices to be adopted in industry.

	POs											PSOs			
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4
CO1	3											3			
CO2	3											2			
CO3	3											2			
CO4	3											3			
CO5	3											3			

LIFE CYCLE ASSESSMENT

Contact Hours/Week	1+0+0 (L+T+P)	Credits	1.0
Total Lecture Hours	15	CIE Marks	50
Sub. Code	S3AEC04	SEE Marks	50

Course objectives:	
1	Define and understand life cycle of project/product
2	Ascertain various data collection techniques
3	Learn various methodology for life cycle assessment
4	Understand life cycle inventory and its importance
5	Learn various factors contribute for the good LCA study

UNIT I
Concepts and Life Cycle Analysis: Introduction, Material flow and waste management, what it all means for an engineer? Water energy and food nexus
3 Hours

UNIT II
Environmental Data Collection and LCA Methodology (Environmental Data Collection Issues, Statistical Analysis of Environmental Data, Common Analytical Instruments, Overview of LCA Methodology - Goal Definition, Life Cycle Inventory, Life Cycle Impact Assessment, Life Cycle Interpretation, LCA Software tools)
3 Hours

UNIT III
Life Cycle Assessment – Detailed Methodology and ISO Framework (Detailed Example on LCA Comparisons, LCA Benefits and Drawbacks, Historical Development and LCA Steps from ISO Framework)
3 Hours

UNIT IV
Life Cycle Inventory and Impact Assessments (Unit Processes and System Boundary Data Quality, Procedure for Life Cycle Impact Assessment, LCIA in Practice with Examples, Interpretation of LCIA Results.
3 Hours

UNIT V
Factors for Good LCA Study: ISO Terminologies, LCA Steps Recap, Chemical Release and Fate and Transport, and Green Sustainable Materials.
3 Hours

Text Books		
1	Mary Ann Curran	Life Cycle Assessment Handbook [electronic resource]: A Guide for Environmentally Sustainable Products), Wiley-Scrivener [Imprint] Oct. 2012 Hoboken: John Wiley & Sons, Inc.

Reference Books		
1	Surjya Narayana Pati	Life Cycle Assessment, Taylor & Francis Ltd; 1e
2	Walter Klöpffer, Birgit Grahl	Life Cycle Assessment (LCA): A Guide to Best Practices, Newark: John Wiley & Sons, ed1, 2014.

Course Outcomes: Upon completion of this course, student will be able to:	
CO1	Appreciate the applicability of LCA in our day to day life
CO2	Demonstrate the knowledge of environmental data collection
CO3	Propose proper methodology for conducting Life Cycle Assessment
CO4	Demonstrate the significance of Life Cycle Inventory and asses its impact
CO5	Recommend Factors for Good LCA Study

	POs											PSOs	
	1	2	3	4	5	6	7	8	9	10	11	1	2
CO1						2							
CO2							2						
CO3				3									
CO4		2											
CO5				3									

SOCIAL CONNECT AND RESPONSIBILITIES

Contact Hours/Week	0+0+2 (L+T+P)	Credits	1.0
Total Lecture Hours	26	CIE Marks	50
Sub. Code	SHS01	SEE Marks	50

Course objectives:	
1	Enable the student to do a deep drive into societal challenges being addressed by NGO(s), social enterprises & the government and build solutions to alleviate these complex social problems through immersion, design & technology.
2	Provide a formal platform for students to communicate and connect with their surroundings.
3	Enable to create of a responsible connection with society.

UNIT I
Plantation and adoption of a tree: Plantation of a tree by Miyawaki Method that will be adopted by entire semester by a group of students. They will also make an excerpt either as a documentary or a photoblog describing the plant's origin, its usage in daily life, and its appearance in folklore and literature.
6 Hours

UNIT II
Heritage walk and crafts corner: Heritage tour, knowing the history and culture of the city, connecting to people around through their history, knowing the city and its craftsman, photoblog & documentary on evolution & practice of various craft forms.
6 Hours

UNIT III
Organic farming: Definition of organic farming, Organically grown crops in India, Differentiate between conventional farming and organic farming, Necessity of organic farming, Key characteristics of organic farming, Four principles of organic farming (principle of Health, principle of ecology, principle of fairness and principle of care),Types of organic farming: 1) Pure organic farming, 2) Integrated farming (Integrated nutrient management and Integrated pest management), objectives of organic farming, benefits, Basic steps and limitations of organic farming.
4 Hours

UNIT IV
Water Conservation: Global Water Scarcity - Global water crisis and its implications; Rainwater Harvesting - Concept and benefits of rainwater harvesting; Water Audit – An approach to water conservation; Efficient Water Use - Optimizing water consumption in daily life.
6 Hours

UNIT V
Food Walk City's culinary practices, food lore, and indigenous materials of the region used in cooking.
4 Hours

Course Outcomes: Upon completion of this course, student will be able to	
CO1	Describe more aware of themselves, and their surroundings towards nature.
CO2	Outline on more about our heritage, culture and city.
CO3	Apply knowledge about organic forming and finding sustainable solutions for growing crops.
CO4	Apply the knowledge about water conservation.
CO5	Explore different Indian customs and traditional food recipes

	POs											PSOs			
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4
CO1	2	2	2		2	2	2		2	2					
CO2						2			2	2					
CO3	2		2	2		2	2		2	2					
CO4	2		2	2		2	2		2	2					
CO5						2			2	2					

AICTE ACTIVITY POINTS

Contact Hours/Week	0+0+2 (L+T+P)	Credits	0.0
Total Lecture Hours	0+0+40	CIE Marks	50
Sub. Code	AAP	SEE Marks	50

IV Semester

MASS TRANSFER– I

Contact Hours/Week	2+2+0 (L+T+P)	Credits	3.0
Total Lecture Hours	26	CIE Marks	50
Total Tutorial Hours	26	SEE Marks	50
Sub. Code	S4CH01	Semester	4

Course Objectives:	
1	Understand basics of diffusion and separation processes for fluid mixtures
2	Understand the fundamentals of mass transfer coefficient and interphase mass transfer
3	Explain the principles of mass transfer and their application to separation and purification processes
4	Demonstrate an ability to design and analyze mass transfer systems

UNIT I
Introduction to Mass Transfer Operations: Classification of mass transfer operations, **Diffusion:** Molecular and Eddy diffusion, Diffusivity, Steady state molecular diffusion in fluids - molecular diffusion in gases and liquids, pseudo steady state diffusion, Diffusion in solids.
5+5 Hours

UNIT II
Mass transfer coefficients and Interphase mass transfer: Mass transfer coefficients, mass transfer theories: Film theory, Penetration theory, Surface renewal theory. **Interphase mass transfer:** Equilibrium, two-phase mass transfer, overall mass transfer coefficient. Types of operations: co-current & counter-current process.
5+5 Hours

UNIT III
Humidification: Adiabatic-Saturation Curves, Dry and Wet bulb temperature, Adiabatic-Saturation Curves, etc., Psychometric chart. Equipment- Cooling towers and its types. **Crystallisation:** Introduction, Theory of Crystallization, Classification of crystallisation equipment.Various crystallisation equipment. Calculation of yields. Material and Energy balances.
6+6 Hours

UNIT IV
Adsorption: Types of adsorption, equilibria, hysteresis, adsorption isotherms, operation: single stage, multistage cross-current, multistage counter-current, Adsorption Equipment: fluidised beds, moving bed adsorber
5+5 Hours

UNIT V
Drying: Introduction to drying operation, Drying rate curves, Mechanism of drying. Equipment: Direct, and indirect batch dryers, and rotary, spray and drum continuous dryers, calculation of time of drying.
5+5 Hours

Text Books		
1	Robert. E. Treybal.	Mass Transfer Operation, 3e, Mc Graw Hill. NY, 2012, ISBN: 978-1259029158
2	Narayanan & Lakshmikutty	Mass Transfer – Theory and Applications, 1e, CBS Publishers, New Delhi, 2005, ISBN: 978-8123924212

Reference Books		
1	Coulson J. II and Richardson J.F.	Chemical Engineering, Vol I and Vol II, 6e, Elsevier India, 2006, ISBN: 978-8181473868
2	Mc Cabe and J.M.Smith	Unit Operations in Chemical Engineering, 7e, 2004, McGraw Hill, ISBN: 9780072848236.
3	Geankoplis C.J.	Transport Processes and Unit Operations, 4e, Prentice Hall of India, New Delhi, 1993, ISBN: 978-0139304392

Course Outcomes: This course will enable students to	
CO1	Apply the fundamentals of mass transfer to solve for diffusion coefficient and mass transfer rates and analyze the solutions
CO2	Apply the concepts of interfacial mass transfer to calculate mass transfer coefficient and mass transfer rates and analyze the solutions
CO3	Solve problems in distillation and perform basic design of distillation columns by applying the concepts of thermodynamic equilibrium and operating lines, analyze and communicate the solutions
CO4	Solve problems in drying and perform basic design of dryers by applying the concepts of thermodynamic equilibrium and drying curve, analyze and communicate the solutions
CO5	Develop humidification and dehumidification systems by applying the fundamentals of humidity, enthalpy and adiabatic saturation curves, analyze and communicate the solutions

	POs											**PSOs**			
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4
CO1	3											3			
CO2		3										3			
CO3		3										3			
CO4		3										3			
CO5		3										3			

PROCESS HEAT TRANSFER

Contact Hours/Week	3+0+2 (L+T+P)	Credits	4.0
Total Lecture Hours	39	CIE Marks	50
Total Practical Hours	26	SEE Marks	50
Sub. Code	S4CHI01	Semester	4

Course objectives: This course will enable students to:	
1	Acquire the knowledge of the basic concepts of conduction, convection, and radiation.
2	Learn about estimation of the heat transfer rate by conduction through different geometries.
3	Design insulation and fins for effective heat transfer.
4	Determine individual and overall heat transfer coefficients in laminar and turbulent flow conditions.
5	Estimate heat transfer coefficient for fluids without and with phase change.

UNIT I
Introduction: Various modes of heat transfer Viz. Conduction, Convection and Radiation. **Conduction**: Fourier's law, Steady state unidirectional heat flow through single and multiple layer slabs, cylinders and spheres with constant and variable thermal conductivities.
8 Hours

UNIT II
Insulation: Properties of insulation materials, Types of insulation, Critical radius and Optimum thickness of insulation. **Extended surfaces:** Fins – Types of fins, fin efficiency and fin effectiveness. Analysis of rectangular fin of uniform cross section, infinitely long fin, fin with insulated end.
8 Hours

UNIT III
Convection: Individual and overall heat transfer coefficient, LMTD, LMTD correction factor. Dimensional numbers - Dimensional analysis, Empirical correlation for forced and natural convection. Analogy between momentum and heat transfer – Reynolds, Colburn and Prandtl analogies. **Heat transfer with phase change:** Boiling phenomena, Nucleate boiling and film boiling. Condensation – Film and Drop wise condensation, Nusselt's equations.
8 Hours

UNIT IV
Heat Transfer Equipment: Double pipe heat exchanger. Shell and tube heatexchangers, Condensers, Construction details. **Evaporators:** Classification of

evaporators, Capacity, Economy, boiling point elevation, heat transfer area of evaporator, Methods of feeding, Vapor recompression evaporators.
8 Hours

UNIT V
Radiation: Properties and definitions-Absorptivity-Reflectivity-Emissivity-Emissive power Black body and intensity of radiation - Kirchoff's law, Stefan-Boltzmann law, Weins displacement law, Planck's law. Radiation between surfaces.
7 Hours

Text Books		
1	Binay K. Dutta	Heat Transfer: Principles and Applications, PHI Publications, New Delhi, 1e, 2000, ISBN:978-8120316256.
2	Frank P. Incropera, David P. Dewitt.	Fundamentals of Heat and Mass Transfer, Wiley India Pvt. Ltd, New Delhi, 6e, 2010, ISBN:978-8126527649
3	Rajput R.K.	Heat and Mass Transfer,S. Chand&Company, New Delhi, 1e, 2008, ISBN:978-8121926171

Reference Books		
1	McCabe and Smith W.L.	Unit Operations of Chemical Engineering, McGraw Hill, New York,7e, 2007, ISBN:978-007118173
2	Coulson J.M and Richardson J.F.	Chemical Engineering, Vol.1, Asian Books, New Delhi, 6e, ISBN:978-81847368.
3	Kern D.Q	Process Heat Transfer, McGraw Hill, New York, 1e, 2017, ISBN:978-0074632178

PROCESS HEAT TRANSFER LABORATORY

Experiments (2 Hours/week)	
1	Estimation of overall heat transfer coefficient and air side heat Transfer coefficient in a bare tube heat exchanger.
2	Estimation of overall heat transfer coefficient and air side heat Transfer coefficient in a finned tube heat exchanger.
3	Estimation of individual and overall heat transfer coefficient in a double pipe heat exchanger.
4	Estimation of individual and overall heat transfer.
5	Coefficient in spiral plate heat exchanger.
6	Estimation of overall heat transfer coefficient in packed bed heat transfer and verification of correlations.
7	Estimation of overall heat transfer coefficient and draw Wilson plot for a vertical condenser.
8	Estimate individual and overall heat transfer coefficient in a shell and tube

	condenser.
9	Determine the overall heat transfer coefficient and critical radius of insulation.
10	Thermal conductivity of insulating powder.
11	Overall heat transfer coefficient of a plate heat exchanger.

Course Outcomes: Upon completion of this course, student will be able to:	
CO1	Apply the concepts of conduction to determine steady-state unidirectional rate of heat transfer through different geometries.
CO2	Design insulation and fins for effective heat transfer.
CO3	Develop equations for convection and apply them to solve problems.
CO4	Design heat transfer equipment and evaporators and evaluate their performance.
CO5	Solve problems on radiation using the laws of radiation.

	POs											PSOs			
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4
CO1	3	2										3	3		
CO2	3	2										2	2		
CO3	3	2										2	2		
CO4	3	2										3	2		
CO5	3	2										3	2		

MECHANICAL OPERATIONS

Contact Hours/Week	3+0+2 (L+T+P)	Credits	4.0
Total Lecture Hours	39	CIE Marks	50
Total Practical Hours	26	SEE Marks	50
Sub. Code	S4CHI02	Semester	4

Course objectives: This course will enable students to:	
1	Understand the fundamentals associated with properties, handling and mixing particulate solids
2	Learn the principles and techniques of size reduction and screening
3	Analyze the principle and applications of filtration
4	Classify the principles and functioning of various solid-fluid operations

UNIT I
Particle Technology: Particle shape, particle size, different ways of expression of particle size, shape factor, sphericity, mixed particle size analysis. screens – ideal and actual screens, Differential and cumulative size analysis, Effectiveness of screen, Specific surface of mixture of particles, Number of particles in a mixture, standard screens industrial screening equipment - Grizzly, Gyratory screen, Vibrating screen, Trommels, Sub sieve analysis – Introduction for Air permeability method, Sedimentation and elutriation methods.
8 Hours

UNIT II
Size reduction: Introduction – Types of forces used for comminution, Criteria for comminution, characteristics of comminuted products, Laws of size reduction, Work Index, Energy utilization, Methods of operating crushers – Free crushing, Choke feeding, Open circuit grinding, Closed circuit grinding, Equipment for size reduction – Blake jaw crusher, Gyratory crusher, Hammer mill, Attrition mill, Ball mill, Critical speed of ball mill, Ultra-fine grinders, Fluid energy mil.
8 Hours

UNIT III
Flow of fluid past immersed bodies: Drag, Drag coefficient, Pressure drop – Ergun equation, Kozeny-Carman equation, Blake-Plummer equation. Fluidization – Conditions for fluidization, Minimum fluidization velocity, Types of fluidization, Applications of fluidization. Motion of particles through fluids: Mechanics of particle motion, equation for one dimensional motion of particles through a fluid in gravitational and centrifugal field, Terminal velocity, Motion of spherical particles in Stokes region, Newton's region, and Intermediate region, Criterion for settling regime, Hindered settling.
8 Hours

UNIT IV
Sedimentation: Batch settling test, application of batch settling test to design of a continuous thickener, Kynch theory, determination of thickener area. Filtration: Introduction, Classification of filtration, Cake filtration, Principles of cake filtration, Modification of Kozeny – Carman equation for filtration. Constant rate filtration and cake filtration, characteristics of filter media, Filter aid, Application of filter aids, industrial filters - Filter press, leaf filter, Rotary drum filter, Horizontal belt filter. Centrifugal filtration – Suspended batch centrifuge.
8 Hours

UNIT V
Agitation and Mixing: Types of impellers. Flow patterns in agitated vessels, Prevention of swirling, Power correlation and calculation. Mixers: Muller mixer, Ribbon blender, internal screw mixer, tumbling mixer. Conveying of solids -Belt conveyors, chain conveyors and bucket elevators.
7 Hours

MECHANICAL OPERATIONS LABORATORY

Experiments (2 Hours/week)	
1	Determine the specific surface area of a given sample power using Air Permeability setup.
2	Find the new surface area created for a given sample using Ball Mill and to find its critical speed.
3	Carry out batch sedimentation test and design the area required to handle for given slurry.
4	Find the particle size distribution and the average size of sub-sieve particle by beaker decantation method.
5	Find the drag co-efficient exerted on a given spiracle particle and verify the laws of settling.
6	Determine the crushing law constants and work index for crushing a known sample using drop weight crusher.
7	Determine the crushing law constants and work index for crushing a known sample using jaw crusher
8	Determine specific cake resistance and filter medium resistance during filtration for a given sample using leaf filter.
9	Determine specific cake resistance and filter medium resistance during filtration for a given sample using plate and frame filter press.
10	Determine the screen effectiveness and the ratio of over flow/feed and Under /flow/feed for a given sample.
11	Determine the pressure drop per unit bed length in fluidized bed.
12	Verify the relationship between the velocity of the fluid and pressure drop per unit length of packing in a packed bed.

Text Books		
1	Warren L. McCabe, Peter Harriott, Julian C. Smith	Unit Operations of Chemical Engineering, McGraw Hill International., 7e, 2022, ISBN:978-9355321084
2	Badger W.L. and Banchero J.T	Introduction to Chemical Engineering, McGraw Hill International Edition, Singapore, 1e, 2017, ISBN: 978- 0074630501

Reference Books		
1	Brown. G.G. et.al.	Unit Operations, CBS Publishers. New Delhi, 1e, 2005, ISBN: 978- 8123910994.
2	A.S. Foust, L. A.Wenzel	Principles of Unit Operations, John Wiley and Sons. New York, 3e, 2008, ISBN:978- 8126518296.
3	R. P. Chhabra and Basavaraj Gurappa	Coulson and Richardson's Chemical Engineering: Vol 2A: Particulate Systems and Particle Technology, Butterworth-Heinemann, 6e, 2019, ISBN-13: 978-0081010983

Course Outcomes: Upon completion of this course, student will be able to:	
CO1	Apply the basic principles of particle characterization in different processes involving solids.
CO2	Evaluate the crushing efficiency of different size reduction equipment by applying crushing laws.
CO3	Select the appropriate equipment for particle separation.
CO4	Analyze the principle of filtration and sedimentation
CO5	Analyze various mixing processes and calculate the power requirement

	POs											PSOs			
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4
CO1	1	2								2	1	1	2		
CO2	2	2								1	2	2	1		
CO3	2	3								1	1	2	1		
CO4	2	2								1	1	2			1
CO5	1	2								2	1	2			1

PROCESS FLOW DIAGRAM LABORATORY

Contact Hours/ Week	0+0+2 (L+T+P)	Credits	1.0
Total Practical Hours	0+0+26	CIE Marks	50
Sub. Code	S4CHL01	SEE Marks	50

Guidelines: The flow sheet will be given to the students and they need to draw the process flow diagram by identifying and adding suitable equipment and accessories using UNISIM Software.

Course objectives: This course will enable students to	
1	Teach the sequential steps involved in an industrial process
2	Train to identify the flow of materials and energy in the process
3	Up skill to draw complex workflows and improve overall process operations
4	Train students to determine potential process problems and inefficiencies
5	Identify areas for improvement and optimization, such as streamlining steps,

	eliminating redundancies, recycling, or reducing waste resources

Experiments
1. Process flow diagram for hydrogenation of Nitrobenzene to Aniline 2. Process flow diagram for Cumene production from Benzene & Propylene 3. Process flow diagram for Methanol production from Carbon & Hydrogen 4. Process flow diagram for Manufacture of Nitric Acid 5. Process Flow Diagram for Manufacture of Formaldehyde 6. Process Flow Diagram for liquefying Oxygen at low pressure (Linde Process) 7. Process Flow Diagram for NGL recovery from natural gas (Expander Process) 8. Process flow diagram for catalytic dehydrogenation of Isopropyl Alcohol 9. Process flow diagram for Sulfur production by oxidation-reduction of H_2S 10. Process flow diagram for Water gas manufacturing process 11. Process flow diagram for Cement Manufacturing. 12. Process flow diagram for Production of bacitracin (antibiotic).
26 Hours

Text Books		
1	S. B. Thakore and B. I. Bhatt	Introduction to Process Engineering Design, 2nd Edition, 2015, Mc Graw Hill
Reference Books		
1	R. K. Sinnott	Chemical Engineering Design, Volume 6, 4e, Elsevier

Course Outcomes: Upon completion of this course, student will be able to	
CO1	Describe the sequential steps involved in an industrial process with a clear understanding of their purpose and interdependencies.
CO2	Illustrate and analyze the flow of materials and energy within industrial systems using appropriate diagrams and tools.
CO3	Interpret and evaluate complex industrial workflows to enhance process understanding and management.
CO4	Identify potential bottlenecks, inefficiencies, and process-related issues using analytical and observational methods.
CO5	Propose improvements for process optimization, including methods for streamlining operations, minimizing waste, improving resource utilization

	POs											PSOs			
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4
CO1	3				3						2	3		2	
CO2	3				3						2	3		2	
CO3	3				3						2	3		2	
CO4	3				3						2	3		2	
CO5	3				3						2	3		2	

CHEMICAL ENGINEERING THERMODYNAMICS

Contact Hours/ Week	3+0+0 (L+T+P)	Credits	3.0
Total Lecture Hours	39	CIE Marks	50
Sub. Code	S4ESC21	SEE Marks	50

Course objectives: This course will enable students to	
1	Introduce to the role of role of thermodynamics, laws of thermodynamics and its application to obtain solutions to basic problems related to chemical industry.
2	Learn about the P-V-T behavior of systems, Equation of States, and Compressibility coefficient and their applications in engineering.
3	Introduce the concepts related to thermodynamic properties of solutions and their significance in behavior of thermodynamic systems.
4	Learn about the phase equilibrium & and its significance in unit operations.
5	Introduce to the concept of Chemical Equilibrium, its significance and estimation of yield of reactions.

UNIT I
P-V-T behavior: P-V-T behavior of pure fluids, Equations of state and ideal gas law, **Processes involving ideal gas law**: Constant volume, constant pressure, constant temperature, adiabatic and polytropic processes. Equations of state for real gases: van der Waals equation, Redlich – Kwong equation, Peng – Robinson equation, Virial equation.
7 Hours

UNIT II
Thermodynamic properties of pure fluids: Reference Properties, Energy Properties, Derived Properties, Work function, Gibbs free energy, Relationships among thermodynamic properties: Gibbs- Helmholtz equation. **Fugacity:** Fugacity, Fugacity coefficient, Effect of temperature and pressure on fugacity, Determination of fugacity of pure gases, Fugacities of solids and liquids, Activity: Effect of temperature and pressure on activity.
8 Hours

UNIT III
Properties of solutions: Partial molar properties, Chemical potential, Fugacity in solutions, Lewis Randall rule, Henry's law, Activity in solutions, Activity coefficient, Gibbs – Duhem equation, Property changes of mixing, excess properties.
6 Hours

UNIT IV
Phase equilibria: Criteria of phase equilibria, Criterion of stability, Duhem's theorem, Vapour – Liquid Equilibria, VLE in ideal solutions, Non-Ideal solutions, VLE at low pressures, VLE at high pressures, Consistency test for VLE data, Calculation of Activity coefficients using Gibbs – Duhem equation, Activity coefficient equations, Liquid-Liquid equilibrium diagrams.
8 Hours

UNIT V
Chemical reaction equilibrium: Reaction Stoichiometry, Criteria of chemical reaction equilibrium, Equilibrium constant and standard free energy change, Effect of temperature, pressure on equilibrium constants and other factors affecting equilibrium conversion, Liquid phase reactions.
9 Hours

Text Books		
1	Narayanan, K.V.	Textbook of Chemical Engineering Thermodynamics, Prentice Hall of India. New Delhi, 2e, 2013, ISBN:978-8120347472
2	Smith J.M. and Vanness H.C.	Introduction to Chemical Engineering Thermodynamics. McGraw Hill, New York, 5e, 2003, ISBN:978-8120347472

Reference Books		
1	Rao Y.V.C.	Chemical Engineering Thermodynamics, New Age International Publication, Nagpur,1e, 1997, ISBN:978-8173710872
2	Tester. J.W and Modell Michael	Thermodynamics and its applications, Prentice hall, New York, 3e, 1996, ISBN:978-0139153563
3	Yunus A. Cengel, Michael A. Boles	Thermodynamics an Engg. Approach, Tata McGraw–Hill, New Delhi, 8e, 2017, ISBN: 978-9339221652

Course Outcomes: Upon completion of this course, student will be able to	
CO1	Illustrate the role of role of thermodynamics and apply the laws of thermodynamics to obtain solutions to basic problems related to chemical industry.
CO2	Demonstrate knowledge about the P-V-T behavior of systems, Equation of States and Compressibility coefficient and their applications in engineering.
CO3	Demonstrate knowledge about the P-V-T behavior of systems, Equation of states and Compressibility coefficient and their applications in engineering.

CO4	Apply the concepts related to thermodynamic properties of solutions to analyse engineering problems.
CO5	Illustrate concepts of the phase equilibrium & and its significance in unit operations.

	POs											PSOs			
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4
CO1	1	2										1			
CO2	1	2										1			
CO3	1	2										1			
CO4	1	2										1			
CO5	1	2										1			

INDUSTRIAL SAFETY ENGINEERING

Contact Hours/Week	3+0+0 (L+T+P)	Credits	3.0
Total Lecture Hours	39	CIE Marks	50
Sub. Code	S4ESC22	SEE Marks	50

Course objectives: This course will enable students to:	
1	Introduce to the basic concepts on safety, risk, occurrence of accidents and their after effects.
2	Learn aboutterminologies adopted in Toxicology and its significance from safety view point, classification of toxic substances, effect of toxic substances on humans and living organisms.
3	Introduce to concept of Industrial Hygiene, laws, international agencies and their standards, their recommendation and maintenance of the same in the industry.
4	Teach about fires and explosion, terminologies and their adoption in the industry.
5	Acquaint with different methods of prevention of fire hazards, its control, reactive chemical hazards and their occurrence in industry.

UNIT I
Introduction: Safety programs, engineering ethics, acceptable risk, inherent safety, seven significant disasters. **Toxicology:** Entry, elimination, and effects of toxicants on organisms, toxicological studies, dose versus response, relative toxicity, and threshold limit values.
8 Hours

UNIT II
Industrial Hygiene: Laws and regulations, OSHA, EPA, DHS, Material Safety Data Sheets. Identification, evaluation, and control of industrial hygiene; personal

protective equipment, respirators, and ventilation.
8 Hours

UNIT III
Fires and Explosions: The fire triangle, distinction between fires and explosions, definitions, flammability characteristics of liquids and vapours. Limiting oxygen concentration and inerting, flammability diagram, ignition energy, auto-ignition, auto- oxidation, adiabatic compression, ignition sources, sprays and mists, explosions.
9 Hours

UNIT IV
Prevention of Fires and Explosions: Inerting, static electricity and its control, explosion-proof equipment and instruments, ventilation, and sprinkler systems, Miscellaneous concepts for preventing fires and explosions. **Chemical Reactivity:** Identification, characterization, and control of reactive chemical hazards.
9 Hours

UNIT V
Hazards Identification: Process hazards checklists, hazards surveys, hazards and operability studies (HAZOP), safety reviews.
5 Hours

Text Books		
1	Crowl, D. A. and Louvar, J.F.,	Chemical Process Safety: Fundamentals with Applications, Prentice Hall, Upper Saddle River, NJ, 3e, 2011, ISBN: 978-9332524057

Reference Books		
1	Speegle, M.	Safety, Health, and Environmental Concepts for the Process Industry, Delmar/Cengage Learning, Clifton Park, NY, 1e, 2013, ISBN: 978-1133013471
2	Sanders, R. E.	Chemical Process Safety: Learning From Case Histories, Elsevier, Burlington, MA, 3e, 2005, ISBN: 978-0128014257.

Course Outcomes: Upon completion of this course, student will be able to	
CO1	Demonstrate the knowledge of the effects of toxic substances on humans organisms.
CO2	Identify, analyze, and recommend control measures for problems related to industrial hygiene.

CO3	Distinguish between fires and explosions and describe the methods for their prevention.
CO4	Identify and characterize reactive chemical hazards and outline methods for their control.
CO5	Explain the different hazard identification procedure.

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CO	POs											PSOs			
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4
1	3	3	1	1	2	3	1	2	3	3	3	3	3		
2	3	2	1	-	-	-	-	-	-	-	-	-	2		
3	3	-	-	-	-	-	-	1	-	-	-	-	-		
4	3	3	2	3	-	2	-	-	-	-	-	3	-		
5	3	3	3	3	3	-	-	2	2	2	-	1	1		

DATA ANALYTICS

Contact Hours/Week	3+0+0 (L+T+P)	Credits	3.0
Total Lecture Hours	39	CIE Marks	50
Sub. Code	S4ESC23	SEE Marks	50

Course objectives:	
1	Identify and classify various types of data and its significance
2	Analyze the data quality
3	Clustering the data for convince of handling and mining
4	Understand various data prediction technique
5	Binary classification of data and predictive method

UNIT I
Introductory Background, Big Data and Data Science, Big Data Architectures, Small Data, A Short Taxonomy of Data Analytics Examples of Data Use, A Project on Data Analytics, The KDD Process The CRISP-DM Methodology. **Descriptive Statistics:** Scale Types, Descriptive Univariate Analysis, Univariate Frequencies, Univariate Data Visualization, Univariate Statistics, Common Univariate Probability Distributions, Descriptive Bivariate Analysis, Two Quantitative Attributes, Two Qualitative Attributes, at Least one of them Nominal, Two Ordinal Attributes.
8 Hours

UNIT II
Descriptive Multivariate Analysis: Multivariate Frequencies, Multivariate Data Visualization, Multivariate Statistics, Location Multivariate Statistics Dispersion Multivariate Statistics, Infographics and Word Clouds, Infographics, Word Clouds, Final Remarks. **Data Quality:** Missing Values, Redundant Data, Inconsistent Data, Noisy Data, Outliers, Converting to a Different Scale Type Converting Nominal to Relative, Converting Ordinal to Relative or Absolute, Converting Relative or Absolute to Ordinal or Nominal, Converting to a Different Scale, Data Transformation, Dimensionality Reduction Attribute Aggregation, Principal Component Analysis, Independent Component Analysis, Multidimensional Scaling, Attribute Selection, Filters, Wrappers, Embedded.
7 Hours

UNIT III
Clustering: Distance Measures, Differences between Values of Common Attribute Types, Distance Measures for Objects with Quantitative Attributes, Distance Measures for Non- conventional Attributes, Clustering Validation, Clustering Techniques,K-means, Centroids and Distance Measures,How K- means Works,DBSCAN, Agglomerative Hierarchical Clustering Technique, Linkage Criterion, Dendrograms. **Frequent Pattern Mining:** Frequent Itemsets, Setting the min_sup Threshold, Apriori – a Join-based Method, Eclat, FP-Growth, Maximal and Closed Frequent Itemsets, Association Rules, Behind Support and Confidence, Cross-support Patterns, Simpson's Paradox Other Types of Pattern, Sequential patterns, Frequent Sequence Mining, Closed and Maximal Sequences.
7 Hours

UNIT IV
Predicting the Unknown Regression: Predictive Performance Estimation, Generalization, Model Validation, Predictive Performance Measures for, Regression, Finding the Parameters of the Model, Linear Regression, Empirical Error, The Bias- variance Trade-off, Shrinkage Methods, Ridge Regression, Lasso Regression, Methods that use Linear Combinations of Attributes, Principal Components Regression, Partial Least Squares Regression, Technique and Model Selection.
7 Hours

UNIT V
Binary Classification, Predictive Performance Measures for Classification, Distance-based Learning Algorithms, K-nearest Neighbor Algorithms, Case-based Reasoning, Probabilistic Classification Algorithms, Logistic Regression Algorithm, Naive Bayes Algorithm. **Additional Predictive Methods:** Search-based Algorithms, Decision Tree Induction Algorithms, Decision Trees for Regression, Model Trees, Multivariate Adaptive Regression Splines, Optimization-based. Algorithms, Artificial Neural Networks, Back propagation,

Deep Networks and Deep Learning Algorithms.	
	9 Hours

Text Books		
1	Moreira,J., Carvalho, A., Horvath, T.	General Introduction to Data Analytics, Wiley, 2018, ISBN: 1119296269

Reference Books		
1	B. Dwarakanath, R. M. Rani, D. Usha,	Fundamentals of data science, Notion press, 2022, ISBN:9798885915717
2	Denis Constales, Gregory S.Yablonsky, Dagmar R. D'hooge, Joris W. Thybaut, Guy B. Marin	Advanced Data Analysis & Modelling in Chemical Engineering, 2017, Elsevier, ISBN: 978-0-444-59485-3

Course Outcomes: Upon completion of this course, student will be able to	
CO1	Appreciate the classification of data and using descriptive statistics for data handling.
CO2	Carry out multivariate data analysis and appreciate the quality of the data.
CO3	Use data clustering as a tool for efficient data mining.
CO4	Conduct data prediction, for predicting missing data. & understanding algorithm for predicting missing data.

	POs											PSOs			
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4
CO	3	3										2	2		
CO	3	3	2									2	2		
CO	3	3										2	2		
CO	3	2	2									2	2		
CO	2	2									2	2	2		

PILOT PLANT AND SCALE-UP METHODS

Contact Hours/Week	3+0+0 (L+T+P)	Credits	3.0
Total Lecture Hours	39	CIE Marks	50
Sub. Code	S4ESC24	SEE Marks	50

Course objectives:	
1	Introduce the concept of pilot plant, model, prototype and similarity laws governing the scale-up method.
2	Learn about the concepts and applications of dimensional analysis and differential equations in scaling up of processes.
3	Learn about application of the similarity criterion for the principal types of regimes in chemical engineering.
4	Acquaint with the scaling up guidelines for unit operation equipment such as distillation column, evaporators, extraction, and absorption processes.
5	Acquaint with the scaling up guidelines for unit operation equipment and unit process equipment.

UNIT I
Introduction: Pilot Plant, Prototypes and models; Principles of similarity: Static, Dynamic, Kinematics, Thermal and Chemical similarities criteria and examples.
8 Hours

UNIT II
Dimensional Analysis, Differential equation, Regime concept.
7 Hours

UNIT III
Scale Up/down equation, extrapolation and boundary effects.
8 Hours

UNIT IV
Scale up problem on transfer operation, momentum heat and mass transfer.
8 Hours

UNIT V
Scale up problems on mixing, agitated vessels and chemical reactors.
8 Hours

Text Books		
1	Johnstone and Thring	Pilot Plant Models and Scale up method in Chemical Engineering, Mc Graw Hill Inc., USA, 1957, ISBN: 978-0070326934
2	Horker and Backhurst	Process Plant Design, Elsevier, 1973, ISBN:9781483162386

Course Outcomes: Upon completion of this course, student will be able to	
CO1	Demonstrate knowledge the concept of pilot plant, model, prototype and similarity laws governing the scale-up method.
CO2	Apply the dimensional analysis and differential equations in getting solutions to scaling up of process problems with constraints.
CO3	Apply the similarity criterion to obtain solutions for scale up problems considering suitable types of regimes.
CO4	Solve problems of scale up related to unit operation equipment such as distillation column, evaporators, extraction, and absorption processes by adopting standard guidelines.
CO5	Solve problems of scale up related to unit operation equipment and unit process equipment adopting standard guidelines.

	POs											**PSOs**			
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4
CO	3	3	2									3	2	2	
CO	3	3	2									3	2	2	
CO	3	3	2									3	2	2	
CO	3	3	2									3	2	2	
CO	3	3	2									3	2	2	

MATERIAL SELECTION FOR MECHANICAL DESIGN

Contact Hours/Week	1+0+0 (L+T+P)	Credits	1.0
Total Lecture Hours	15	CIE Marks	50
Sub. Code	S4AEC01	SEE Marks	50

Course objectives: This course will enable students to	
1	Introduce to the concepts of materials for design and selection.
2	Acquaint with the usage of material data charts.
3	Introduce to the various methods of martial processing and their design.
4	Learn about t proper material under given constraints.
5	Acquaint with suitable data source for selecting materials for design.

UNIT I
Materials in Design: The Evolution of Engineering Materials, the process of design and its type. Design tools and material data.
3 Hours

UNIT II
Classification of engineering material based on its properties. Reading and understanding various charts for selection of material.
3 Hours

UNIT III
The selection strategy, deriving property limits and material indices. The selection procedure and structural index.
3 Hours

UNIT IV
Materials processing and design: processes and their influence on design, processes and their influence on design, systematic process selection. screening: process selection diagrams, ranking: process cost
3 Hours

UNIT V
Case studies: process selection: fabricating a pressure vessel, forming ceramic tap valves. **Multiple constraints and compound objectives**: Selection by successive application of property limits and indices. The method of weight-factors, methods employing fuzzy logic, systematic methods for multiple constraints, compound objectives, exchange constants and value-functions. Few case studies on multiple constraints and compound.
3 Hours

Text Books		
1	Michael F. Ash.	Materials Selection in Mechanical Design, Butterworth - Heinemann, 4e, 2010, ISBN:978-9380931722

Reference Books		
1	Myer Kutz	Handbook of Materials Selection, Wiley, 1e, 2002, ISBN: 978-0-471-35924-1
2	Richard G. Budynas , J. Keith Nisbett	Shigley's Mechanical Engineering Design (in SI Units), McGraw Hill, 11e, 2020, ISBN: 978-9390219636.

Course Outcomes: Upon completion of this course, student will be able to:	
CO1	Illustrate knowledge about materials and their classification for design and selection.
CO2	Demonstrate usage of material data charts.
CO3	Illustrate about various methods of material processing and their design.
CO4	Identification of appropriate materials under given constraints.
CO5	Select suitable data source for selecting materials for design.

		POs											PSOs			
		1	2	3	4	5	6	7	8	9	10	11	1	2	3	4
COs	CO1	3	2	1									2			
	CO2	3	2	1									1			
	CO3	3	2	1									2			
	CO4	3	2	1									2			
	CO5	3	2	1									2			

WATER AND WASTEWATER CHARACTERIZATION

Contact Hours/Week	1+0+0 (L+T+P)	Credits	1.0
Total Lecture Hours	15	CIE Marks	50
Sub. Code	S4AEC02	SEE Marks	50

Course objectives:	
1	Know the types of pollutant, permissible concentration in different types of water and wastewater.
2	Learn aboutthe physical, chemical and biological characteristics of water and wastewater.
3	Study aboutthe chemical characteristics of water and wastewater.
4	Understand about the physical, chemical and biological characteristics of water and wastewater.
5	Learn aboutthe various standard procedures adopted to analyze the wastewater quality.

UNIT I
Introduction: Water resources, Origin of wastewater, Classification, Types of water pollution, Effects of water pollution, Legislation, regulations, and government agencies; Water (Prevention and Control of Pollution) Act.
3 Hours

UNIT II
Wastewater Characteristics: water quality standards for various water uses **Physical characteristics**: colour, odour, temperature, turbidity, total solids.
3 Hours

UNIT III
Chemical characteristics: Organic compounds: BOD, COD, pH, Alkalinity, Acidity, Hardness, Dissolved Oxygen, Nitrogen content, Nitrate, Fluoride, Arsenic, Heavy metals, Pesticides, other Inorganic components and their determination.
3 Hours

UNIT IV
Biological Characteristics: Classification of microorganisms, pathogenic organisms, Toxicity, Estimation of BOD, COD, bio- kinetic constants and their determination.
3 Hours

UNIT V
Analysis of wastewater quality parameters: Sources, method of sample collection, Standard methods of measurements for pH, acidity, alkalinity, turbidity, chemical oxygen demand, Dissolved oxygen, Biochemical Oxygen Demand, Determination of dissolved oxygen, suspended and volatile solids, Optimum coagulant dosage using Jar test.
3 Hours

Textbooks		
1	Mark J. Hammer, Jr.,	Water and Wastewater Technology, PHI Learning Private Ltd., New Delhi,7e, 2012. ISBN:9780135114049
2	Patwardhan, A.D.	Industrial Waste Water Treatment, PHI learning, 2e, 2017, ISBN:978-81- 203-3350-5

Reference books		
1	Metcalf & Eddy	Wastewater Engineering Treatment and Reuse, McGraw Hill Education Private Ltd. New York, 5e, 2014, ISBN: 7-302-05857-1.
2	Eckenfelder, W.W.	Industrial Water Pollution Control, McGraw- Hill, 1e, 2001, ISBN: 9780070393646.

3	Don W. Green; Robert H. Perry	Perry's Chemical Engineers' Handbook, McGraw-Hill education, New York, 8e, 2008, ISBN: 9780071422949.

Course Outcomes: Upon completion of this course, student will be able to	
CO1	Illustrate knowledge about water pollution, sources of pollution and their impact on environment, humans and other living beings.
CO2	Outline the standards for potable water and permissible limits of pollutants for various types of waste water.
CO3	Demonstrate knowledge about the physical characteristics of waste water.
CO4	Identify the chemical and biological characteristics of waste water.
CO5	Explain the standard methods for estimation of important parameters of wastewater.

		POs											**PSOs**			
		1	2	3	4	5	6	7	8	9	10	11	1	2	3	4
COs	CO1	2					3							3		
	CO2	2					3							3		
	CO3	2					3							3		

UNDERSTANDING EQUIPMENT DATA SHEET

Contact Hours/Week	1+0+0 (L+T+P)	Credits	1.0
Total Lecture Hours	15	CIE Marks	50
Sub. Code	S4AEC03	SEE Marks	50

Course objectives: This course will enable students to	
1	Give a better understanding of equipment design and operating principles
2	Help order the right equipment
3	Enables adherence to accurate specification standards
4	Prepare the data sheet pertaining to the process

UNIT I
Process Flow Diagram, Basics of Data Sheets and Specifications.
3 Hours

UNIT II
Types of data sheets -process data sheet, instrument data sheet, piping and instrumentation diagram,
3 Hours

UNIT III
Utility head diagram, product data sheet, material safety data sheet
3 Hours

UNIT IV
Exercises on data sheets to capture information pertaining to process, mechanical and electrical
3 Hours

UNIT V
Exercises on data sheets to Control requirements for equipment and instruments.
3 Hours

Text Books		
1	Stephen Hall,	Rules of Thumb for Chemical Engineers, Butterworth-Heinemann, Fifth Edition, 2012, ISBN 978-0-12-387785-7

Reference Books		
1	R. K. Sinnott	Practice and Economics of Plant and Process Design
2	R.K. Sinnott, Gavin Towler	Chemical Engineering: Chemical Engineering Design-Vol.6, 5e, Butterworth-Heinemann, 2021
3	Mihir Patel	Mihir's Handbook of Chemical Process Engineering, 2018, ISBN 9352796985

Course Outcomes: This course will enable students to	
CO1	Ability to work in collaborative manner with others in a team.
CO2	Familiarize with different data specification sheets
CO3	Prepare the technical specification sheet
CO4	Identify the needs and applications of equipment data sheets.
CO5	Analyse the data sheet prepared to control the equipment

		POs											**PSOs**			
		1	2	3	4	5	6	7	8	9	10	11	1	2	3	4
COs	CO1		3							2					3	
	CO2		3							2					3	
	CO3		3							2					3	
	CO4		3							2					3	
	CO5		3							2					3	

DATA ANALYTICS WITH EXCEL

Contact Hours/Week	1+0+0 (L+T+P)	Credits	1.0
Total Lecture Hours	15	CIE Marks	50
Sub. Code	S4AEC04	SEE Marks	50

Course objectives: This course will enable students to	
1	Apply analysis techniques to datasets in Excel.
2	Learn how to use Pivot Tables and Pivot Charts to streamline your workflow in Excel.
3	Asquint with the principles of data analysis.
4	Acquire with using Excel functions and techniques for analysis.
5	Build presentation ready dashboards in Excel.

List of Exercises	
1	Getting Started with Excel: Creation of spread sheets, Insertion of rows and columns, Drag & Fill, use of Aggregate functions.
2	Working with Data: Importing data, Data Entry & Manipulation, Sorting & Filtering.
3	Working with Data: Data Validation, Pivot Tables & Pivot Charts.
4	Data Analysis Process: Conditional Formatting, What-If Analysis,Data Tables, Charts & Graphs.
5	Cleaning Data with Text Functions: use of UPPER and LOWER, TRIM function, Concatenate.
6	Cleaning Data Containing Date and Time Values: use of DATEVALUE function, DATEADD and DATEDIF, TIMEVALUE functions.
7	Conditional Formatting: formatting, parsing, and highlighting data in spreadsheets during data analysis.
8	Working with Multiple Sheets: work with multiple sheets within a workbook is crucial for organizing and managing data perform complex calculations and create comprehensive reports.
9	Create worksheet with following fields: Empno, Ename, Basic Pay (BP), Travelling Allowance (TA), Dearness Allowance (DA), House Rent Allowance (HRA), Income Tax (IT), Provident Fund (PF), Net Pay (NP). Use appropriate formulas to calculate the above scenario Analyze the data using appropriate chart and report the data.
10	Create worksheet on Inventory Management: Sheet should contain Product code, Product name, Product type, MRP, Cost after % of discount, Date of purchase. Use appropriate formulas to calculate the above scenario. Analyze the data using appropriate chart and report the data.
11	Create worksheet on Sales analysis of Merchandise Store: data consisting of Order ID, Customer ID, Gender, age, date of order, month, online platform, Category of product, size, quantity, amount, shipping city and other details. Use of formula to segregate different categories and perform a comparative study using pivot tables and different sort of charts.
12	Generation of report & presentation using Auto-filter &macro.

Text Books		
1	Manisha Nigam	Data Analysis with Excel, BPB Publications, New Delhi, 1e, 2019, ISBN: 978-9388176675.

2	Brain D Bissett	Automated Data Analysis using Excel, Chapmen and Hall/CRC Publications,USA, 1e,2020, ISBN:978-0367509316

Reference Books		
1	Manohar H Lysender	Data Analysis and Business Modelling using Microsoft Excel, PHI Publications, New Delhi, 1e, 2016, ISBN:978-8120352889.
2	Gordon S Linoff	Data Analysis using SQL and Excel, Wily Publishers, USA, 1e, 2015, ISBN:978-1119021438.

Course Outcomes: Upon completion of this course, student will be able to	
CO1	Use advanced functions and productivity tools to assist in developing Work sheets.
CO2	Manipulate data lists using Outline and PivotTables.
CO3	Use Consolidation to summarize and report results from multiple worksheets.
CO4	Apply Macros and Auto filter to solve the given real world scenario.

	POs											**PSOs**			
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4
CO 1	3	3	2					2	2			3	2		
CO 2	3	3	2					2	2			3	2		
CO 3	3	3	2					2	2			3	2		
CO 4	3	3	2					2	2			3	2		

BIOLOGY FOR ENGINEERS

Contact Hours/ Week	3+0+0 (L+T+P)	Credits	3.0
Total Lecture Hours	39	CIE Marks	50
Sub. Code	S4CCA01	SEE Marks	50

Course objectives: This course will enable students to:	
1	Familiarize the students with the basic biological concepts and their engineering applications.
2	Enable the students with an understanding of biodesign principles to create novel devices and structures.
3	Provide the students an appreciation of how biological systems can be re-designed as substitute products for natural systems.
4	Motivate the students to develop interdisciplinary vision of biological engineering

UNIT I
Introduction to Biology: The cell: the basic unit of life, Structure and functions of a cell. The Plant Cell and animal cell, Prokaryotic and Eukaryotic cell, Stem cells and their application. Biomolecules: Properties and functions of Carbohydrates, Nucleic acids, proteins, lipids. Importance of special biomolecules; Enzymes (Classification (with one example each), Properties and functions), vitamins and hormones.
8 Hours

UNIT II
Biomolecules and their Applications (Qualitative): Carbohydrates (cellulose-based water filters, PHA and PLA as bioplastics), Nucleic acids (DNA Vaccine for Rabies and RNA vaccines for Covid19, Forensics – DNA fingerprinting), Proteins (Proteins as food – whey protein and meat analogs, Plant based proteins), lipids (biodiesel, cleaning agents/ detergents), Enzymes (glucose-oxidase in biosensors, lignolytic enzyme in bio-bleaching).
8 Hours

UNIT III
Human Organ Systems and Bio Designs (Qualitative): Brain as a CPU system (architecture, CNS and Peripheral Nervous System, signal transmission, EEG, Robotic arms for prosthetics. Engineering solutions for Parkinson's disease). Eye as a Camera system (architecture of rod and cone cells, optical corrections, cataract, lens materials, bionic eye). Heart as a pump system (architecture, electrical signalling - ECG monitoring and heart related issues, reasons for blockages of blood vessels, design of stents, pace makers, defibrillators). Lungs as purification system (architecture, gas exchange mechanisms, spirometry, abnormal lung physiology - COPD, Ventilators, Heart-lung machine). Kidney as a filtration system (architecture, mechanism of filtration, CKD, dialysis systems).
8 Hours

UNIT IV
Nature-Bioinspired Materials and Mechanisms (Qualitative): Echolocation (ultrasonography, sonars), Photosynthesis (photovoltaic cells, bionic leaf). Bird flying (GPS and aircrafts), Lotus leaf effect (Super hydrophobic and self- cleaning surfaces), Plant burrs (Velcro), Shark skin (Friction reducing swim suits), Kingfisher beak (Bullet train). Human Blood substitutes-hemoglobin-based oxygen carriers (HBOCs) and perflourocarbons (PFCs).
8 Hours

UNIT V
Trends in Bioengineering (Qualitative): Muscular and Skeletal Systems as scaffolds (architecture, mechanisms, bioengineering solutions for muscular dystrophy and osteoporosis), scaffolds and tissue engineering, Bioprinting techniques and materials, 3D printing of ear, bone and skin. 3D printed foods. Electrical tongue and electrical nose in food science, DNA origami and Biocomputing, Bioimaging and Artificial Intelligence for disease diagnosis. Self-healing Bioconcrete (based on bacillus spores, calcium lactate nutrients and biomineralization processes) and Bioremediation and Biomining via microbial surface adsorption (removal of heavy metals like Lead, Cadmium, Mercury, Arsenic).
8 Hours

Textbooks:		
1	Arthur T. Johnson	Biology for Engineers, CRC Press, Taylor and Francis, 2011, ISBN: 978-1420077636.
2	Leslie Cromwell et. al.	Biomedical Instrumentation and Measurements, Prentice Hall, 2e, 2015, ISBN:978-8120306530.
3	Sohini Singh and Tanu Allen	Biology for Engineers, Vayu Education of India, New Delhi, 2014, ISBN:978-1429834763.

E-Resources	
1	https://nptel.ac.in/courses/121106008
2	https://freevideolectures.com/course/4877/nptel-biology-engineers-other-non-biologists
3	https://ocw.mit.edu/courses/20-020-introduction-to-biological engineering-design-spring-2009
4	https://ocw.mit.edu/courses/20-010j-introduction-to-bioengineering-be-010j-spring-2006
5	https://www.coursera.org/courses?query=biology
6	https://onlinecourses.nptel.ac.in/noc19_ge31/preview
7	https://www.classcentral.com/subject/biology
8	https://www.futurelearn.com/courses/biology-basic-concepts

Course Outcomes: Upon completion of this course, student will be able to	
CO1	Elucidate the basic biological concepts via relevan industrial applications and case studies.
CO2	Evaluate the principles of design and development, for exploring novel bioengineering projects.
CO3	Corroborate the concepts of biomimetics for specific requirements.
CO4	Think critically towards exploring innovative biobased solutions for socially relevant problems.

CO	COs											POs		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
1	2	2												3
2	2	2	3											3
3	2	2	3											3
4	2	2												3
5	2	2				2	2							3

UNIVERSAL HUMAN VALUES

Contact Hours/ Week	2+0+0+0 (L+T+P+S)	Credits	1.0
Total Lecture Hours	24	CIE Marks	50
Sub. Code	SHS04	SEE Marks	50

Pre-requisites: Universal Human Values (conducted during induction programme)

Course objectives: This course will enable students to	
1	Understanding of self-exploration about themselves (human beings), family, society and nature/existence.
2	Appreciating the harmony in the human being, family, society and Nature / existence.
3	Strengthening holistic perception of co-existence and mutual fulfillment among the four orders of nature.

UNIT I
Understanding Harmony in the Human Being - Harmony in self: Understanding human being as a co-existence of the sentient 'I' and the material 'Body'; Understanding the needs of Self ('I') and 'Body' - happiness and physical facility; Understanding the Body as an instrument of 'I' (I being the doer, seer and enjoyer); Understanding the characteristics and activities of 'I' and harmony in 'I'.
3 Hours

UNIT II
Understanding Harmony in self and body: Understanding the harmony of 'I' with the Body: Sanyam and Health, correct appraisal of Physical needs, meaning of Prosperity in detail, include discussions to differentiate between i) Prosperity and accumulation. ii) Ensuring health vs. dealing with disease.
2 Hours

UNIT III
Understanding Harmony in the Family - Harmony in Human-Human Relationship: Understanding values in human - human relationship, meaning of Justice (nine universal values in relationships) and program for its fulfillment to ensure mutual happiness, Trust and Respect as the foundational values of relationship; Understanding the meaning of Trust, Difference between intention and competence; Understanding the meaning of Respect, Difference between respect and differentiation; the other salient values in relationship.
3 Hours

UNIT IV
Understanding Harmony in Society and Nature: Understanding the harmony in the society (society being an extension of family)- Resolution, Prosperity, fearlessness (trust) and co-existence as comprehensive Human Goals. Understanding the harmony in the Nature; Interconnectedness and mutual fulfillment among the four orders of nature- recyclability and self-regulation in nature.
2 Hours

UNIT V
Understanding Harmony in all levels of Existence: Understanding Existence as Co-existence of mutually interacting units in all-pervasive space; Holistic perception of harmony at all levels of existence. Include discussions on-human being as cause of imbalance in nature (film "Home" can be used), pollution, depletion of resources and role of technology etc.
3 Hours

Textbooks		
1	Gaur, R.R. and Sangal R	Foundation Course in Human Values and Professional Ethics; Presenting a universal approach to value education through self-exploration', Excel Books, Bangalore, 2016, ISBN: 978-8-174-46781-2

Reference Books		
1	Tripathi A.N.	Human Values, New Age International Publisher, 2003, ISBN: 81-224-1426-5

Web Resources:	
1	Story of Stuff, http://www.storyofstuff.com
2	https://www.youtube.com/channel/UCQxWr5QB_eZUnwxSwxXEkQw
3	https://fdp-si.aicte-india.org/8dayUHV_download.php
4	https://www.youtube.com/watch?v=8ovkLRYXIjE
5	https://www.youtube.com/watch?v=OgdNx0X923I

Course Outcomes: Upon completion of the course, student will be able to:	
CO1	Become more aware of themselves, and their surroundings (family, society, nature).
CO2	Become more responsible in life, and value human relationships and human society.
CO3	Have better critical ability sustainable solutions in handling problems and in finding

CO	**COs**											POs	
	1	2	3	4	5	6	7	8	9	10	11	1	2
1	-	-	-	-	-	1	1	1	1	1	1	-	-
2	-	-	-	-	-	3	3	2	1	1	2	-	-
3	-	-	-	-	-	3	3	2	1	1	2	-	-
4	-	-	-	-	-	3	3	2	1	1	2	-	-
5	-	-	-	-	-	3	3	2	1	1	2	-	-

AICTE ACTIVITY POINTS

Contact Hours/ Week	0+0+2 (L+T+P)	Credits	0.0
Total Lecture Hours	0+0+40	CIE Marks	50
Sub. Code	AAP	SEE Marks	50