SCHEME & SYLLABUS

OF

III & IV SEMESTERS

B.E. CHEMICAL ENGINEERING

2023-2024

[for 2022 admitted batch,

160 credit course, NEP 2.0]

Department Chemical Engineering SIT, Tumakuru-572103

About Institute:

Siddaganga Institute of Technology (SIT) was established in the year 1963 by Siddaganga Education Society, as a private self-financing institution with the following vision and mission.

Vision of the Institute:

To develop thoughtful and creative young minds in a learning environment of high academic ambience by synergizing spiritual values and technological competence.

Mission of the Institute:

- To continuously strive for the total development of students by educating them in state-of-the art technologies and managerial competencies providing best in class learning experience with emphasis on skills, values and learning outcomes and helping them imbibe professional ethics and societal commitment.
- To create research ambience that promotes interdisciplinary research catering to the needs of industry and society.
- To collaborate with premier academic and research institutions and industries to strengthen multidisciplinary education, applied research, innovation, entrepreneurship and consulting ecosystems.

Quality Policy:

Siddaganga Institute of Technology is committed to:

- Impart quality education by establishing effective learning-teaching – learning processes to produce competent engineers with high professional ethics and social responsibility.
- Create congenial environment and provide state-of-the-art infrastructure.
- Continually improve the effectiveness of the quality management system.
- Satisfy all applicable requirements.

Vision of the Department:

To be an internationally renowned department for chemical engineering education and research meeting the aspirations of society.

Mission of the Department:

M1. To impart quality education in chemical engineering at all levels.

M2. To foster cutting edge research and development in chemical engineering. M3. To produce responsible and ethical engineers to serve society.

Program Educational Objectives (PEOs)

The Program Educational Objectives of the program are:

The graduates shall possess

1. a sound knowledge of chemical engineering to pursue a successful professional career.
2. a spirit of inquiry and urge to pursue research in chemical engineering and thrust areas.
3. high ethical values and be socially responsible in discharging their duties.
4. knowledge of the latest developments in their field of activity and commit themselves to life-long learning.

Program Specific Outcomes (PSOs):

The following are the PSOs defined by the Chemical Engineering department:

PSO-1: Graduates will be able to apply the knowledge of science and transport process for production and separation of chemicals in chemical and allied industries

PSO-2: Graduates will be able to analyze processes/equipment taking into consideration, process safety, project engineering, economics and environmental aspects.

PSO-3: Graduates will be able to analyze processes using process control, process optimization and integration using modelling/simulation tools for process development

PSO-4: Graduates will be able to design chemical equipment for a given process.

Program Outcomes:

The following are the Program Outcomes:

1. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

2. **Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

3. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with

appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

4. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

6. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

7. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

8. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. **Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

12. **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-

long learning in the broadest context of technological change.

The above POs are achieved through curriculum that offers courses under mathematics and basic sciences, basic engineering courses, professional core, professional electives, laboratory courses, open electives, humanity courses, projects, technical seminar and the industrial training and mandatory courses. Each course under these course components have COs that are mapped to the POs. The attainment of POs is achieved through attaining the COs.

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B.E. in Chemical Engineering NEP-2.0

SCHEME OF TEACHING AND EXAMINATION (2022 Scheme) (w.e.f. 2023-24)

III Semester

Sl. No.	Course and Course Code		Course Title	Teaching / Paper setting Dept.	Teaching hrs./week				Examination				Credit
					Lecture	Tutorial	Practical/ Drawing	Self-Study Component	Duration in hrs.	CIE Marks	SEE Marks	Total Marks	
					L	T	P	S					
1.	BSC	S3MAT1	Probability and statistics	Dept. / Maths	3	0	0		3	50	50	100	3
2.	IPCC	S3CHI01	Momentum transfer	CH.	2	2	2		3	50	50	100	4
3.	IPCC	S3CHI02	Technical Chemistry	Chy.	3	0	2		3	50	50	100	4
4.	PCC	S3CH01	Process calculations	CH.	3	0	0		3	50	50	100	3
5.	PCCL	S3CHL01	Computer Aided Equipment Drawing	CH	0	0	2		2	50	50	100	1
6.	ESC	S3ESCXX	ESC/ETC/PLC	Dept.	3	0	0		3	50	50	100	3
7.	UHV	S3UHV01	Social Connect and Responsibility **(Board: ME)**	Dept.	0	0	2		-	100	-	100	1
8.	AEC/ SEC	S3AECXX	**Ability Enhancement Course/ Skill Enhancement Course – III**	Dept.	If offered as Theory Course				1½	50	50	100	1
					1	0	0						
					If offered as Integrated Course				1½				
					0	0	2						
9.	NCMC	SMC01	National Service Scheme (NSS)	NSS	0	0	2			100	-	100	0
		SMC02	Physical Education (PE) (Sports and Athletics)	PED									
		SMC03	Yoga	Yoga									
			Total							**550**	**350**	**900**	**20**
		AAP	AICTE Activity Points (Applicable for both Regular and Lateral Entry students)	40 hours community service to be documented and produced for the examination									

Note: **PCC**: Professional Core Course, **IPCC**: Integrated Professional Core Course, **PCCL**: Professional Core Course laboratory, **UHV**: Universal Human Value Course, **NCMC**: Non Credit Mandatory Course, **AEC**: Ability Enhancement Course, **SEC**: Skill Enhancement Course, **ESC**: Engineering Science Course, **ETC**: Emerging Technology Course, **PLC**: Programming Language Course
L: Lecture, **T**: Tutorial, **P**: Practical **S= SDA**: Skill Development Activity, **CIE**: Continuous Internal Evaluation, **SEE**: Semester End Evaluation

Engineering Science Course (ESC/ETC/PLC) (Offered by the Department)

S3ESC11	**Material Science and Engineering**	S3ESC12	**Introduction to Polymer Science in Technology**

Ability Enhancement Course – III (Offered by the Department)

S3AEC01	**Basic Laboratory Practices and Data Analysis**	S3AEC02	**MS Excel for Data Analysis**

Integrated Professional Core Course (IPCC): Refers to Professional Core Course Theory Integrated with practical of the same course. Credit for IPCC can be 04 and its Teaching–Learning hours (L : T : P) can be considered as (3 : 0 : 2) or (2 : 2 : 2). The theory part of the IPCC shall be evaluated both by CIE and SEE. The practical part shall be evaluated by only CIE (no SEE). However, questions from the practical part of IPCC shall be included in the SEE question paper. For more details, the regulation governing the

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Degree of Bachelor of Engineering (B.E.) 2022-23 may please be referred.

National Service Scheme /Physical Education/Yoga: All students have to register for any one of the courses namely National Service Scheme (NSS), Physical Education (PE)(Sports and Athletics), and Yoga(YOG) with the concerned coordinator of the course during the first Week of III semesters. Activities shall be carried out between III semester to the VI semester (for 4 semesters). Successful completion of the registered course and requisite CIE score is mandatory for the award of the Degree. The events shall be appropriately scheduled by the colleges and the same shall be reflected in the calendar prepared for the NSS, PE, and Yoga activities. These courses shall not be considered for vertical progression as well as for the calculation of SGPA and CGPA, but completion of the course is mandatory for the award of Degree.

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B.E. in Chemical Engineering NEP-2.0

SCHEME OF TEACHING AND EXAMINATION (2022 Scheme) (w.e.f. 2023-24)

IV Semester

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					
1.	PCC	S4CH01	Chemical Engineering Thermodynamics	Dept.	3	0	0		3	50	50	100	3
2.	IPCC	S4CHI01	Process Heat Transfer	Dept.	2	2	2		3	50	50	100	4
3.	IPCC	S4CHI02	Mechanical Operations	Dept.	2	2	2		3	50	50	100	4
4.	PCCL	S4CHL01	Computational Methods for Chemical Engineering	Dept.	0	0	2		3	50	50	100	1
5.	ESC	S4ESCXX	ESC/ETC/PLC	Dept.	3	0	0		3	50	50	100	3
6.	BSC	S4ACCA01	Biology for Engineers **(Board: BT)**	BT, CH, Phy, Che	3	0	0		3	50	50	100	3
7.	UHV	SHS02	Universal Human Values Course **(Board: IEM)**	Dept.	1	0	0		1½	50	50	100	1
8.	AEC/ SEC	S4AECXX	**Ability Enhancement Course/ Skill Enhancement Course – IV**	Dept.	If offered as Theory Course				1½	50	50	100	1
					1	0	0						
					If offered as Integrated Course				1½				
					0	0	2						
9.	NCMC	SMC01	National Service Scheme (NSS)	NSS	0	0	2			100	-	100	0
		SMC02	Physical Education (PE) (Sports and Athletics)	PED									
		SMC03	Yoga	Yoga									
			Total							**500**	**400**	**900**	**20**
		AAP	AICTE Activity Points (Applicable for both Regular and Lateral Entry students)	40 hours community service to be documented and produced for the examination									

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Engineering Science Course (ESC/ETC/PLC) (Offered by the Department)			
S4ESC11	Petroleum refining Technology	S4ESC12	Industrial Safety Engineering
S4ESC13	Data Analytics	S4ESC14	Pilot Plant and Scale-up Methods
Ability Enhancement Course – IV (Offered by the Department)			
S4AEC11	Introduction to Process Technology	S4AEC12	Water and Waste Water Characterization
S4AEC13	Process Economics	S4AEC14	Data Analytics with Excel

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Statistics and Probability

Course name	Statistics and Probability	Course credits	3.0
Course code	S3MAT1	L+T+P	3+0+0
Total No. of Contact Hours	Theory:39 hrs		

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. Introduce the basic concepts and applications of probability in engineering.
3. Acquaint about the random variables, random process and how to model the random processes in engineering.
4. Deal with multiple random variables and introduction of the most important types of stochastic processes.
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, Definitions, Curve Fitting: Straight line, parabola and exponential curves. Correlation and regression, formula for correlation coefficient, regression lines and angle between the regression lines. **7 Hrs**

UNIT-II

Probability: Basic terminology, Definition of probability, Probability and set notations, Addition law of probability, independent events, conditional probability, multiplication law of probability, Baye's theorem. **8 Hrs**

UNIT-III

Random Variable: Discrete Probability distribution, Continuous Probability distribution, expectation, Variance, Binomial distribution, Poisson distribution, Normal distribution and Exponential distributions. **8 Hrs**

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 Hrs**

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 Hrs**

TEXTBOOKS:

B.S.Grewal	Higher Engineering Mathematics, Khanna Publications, 43e, 2015, ISBN:978-81-7409-195-5
Ramana .B.V	Higher EngineeringMathematics**,** latest edition, Tata-McGraw Hill, 2016, ISBN:0-07-053516-7

REFERENCE BOOKS:

Erwin Kreyszig	Advanced Engineering Mathematics, Wiley Publications, 10e, 2015, ISBN:978-81-7409-195-5
C. Ray Wylie And Louis C. Barrett	Advanced EngineeringMathematics, Tata-McGraw Hill, 6e, 2015, ISBN: 978-0070582378
Louis A. Pipes and Lawrence R. Harvill	Applied Mathematics for Engineers and Physicists, McGraw Hill, 3e, 2014, ISBN:978-0486779515

Course Outcomes:

Upon completion of this course the student will be able to:

1. Apply least square method to fit a curve for the given data and evaluate the correlation coefficient and regression lines for the data
2. Analyse the nature of the events and hence determine the appropriate probabilities of the events

3. Classify the random variables to determine the appropriate probability distributions.
4. Determine the joint probability distribution, its mean, variance and covariance. Calculate the transition matrix and fixed probability vector for a given Markov chain
5. Estimate the parameter of a population, important role of normal distribution as a sampling distribution

MOMENTUM TRANSFER

Course name	Momentum Transfer	Course credits	4.0
Course code	S3CHI01	L+T+P	2+2+2
Total No. of Contact Hours	Theory: 26 hrs Tutorials: 26 hrs Lab classes: 26 hrs		

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.
6. Learn skills to analyse obtained results and submit a technical report.

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 $1/7^{th}$ 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**

TEXTBOOKS:

Cengel Y. A., and Cimbala J. A	Fluid Mechanics – Fundamentals and Applications, Mc Graw Hill, 2e, 2013, ISBN: 0-07-247236-7
Pati, S	Text Book of Fluid Mechanics and Hydraulic Machines, Mc Graw Hill, 1e, 2017, ISBN: 978-1259006234
Fox and McDonald's	Introduction to Fluid Mechanics, Wiley India Pvt Ltd, 10e, ISBN: 978-354641077

REFERENCE BOOKS:

Coulson J R and Richardson J F	Chemical Engineering Vol. I, Asian Books, New Delhi, 6e, 2006, ISBN:978-81847368
Badger W Iand Banchero J T	Introduction to Chemical Engineering, Tata McGraw Hill, New Delhi, 1e, 2017, ISBN: 978-0074630501
James Wilkes	Fluid Mechanics for Chemical Engineers: with Microfluidics, CFD, and COMSOL Multiphysics 5 (International Series in the Physical and Chemical Engineering Sciences), Pearson; 3e, 2017, ISBN-13:978-0134712826

Momentum Transfer Laboratory: 2 Hrs/week

The experiments are based on the following topics:

1) To study the variation of friction factor with Reynolds number and to plot the universal resistance graph
2) To find the hydraulic Coefficient of orifice, Coefficient of contraction and Coefficient of velocity
3) To calibrate the given Orifice meter and to find out its coefficient discharge
4) To calibrate the given venturi meter and to find out its coefficient discharge
5) To determine the notch constants for a given triangular notch
6) To compare the pressure drop in a helical coil with that in a

straight pipe of same length, inside diameter and surface roughness

7) To 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
8) To study the characteristics of a centrifugal pump
9) Determination of viscosity of the fluid using capillary viscometer
10) Analysis of venturi-meter by virtual experiment

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

1. 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.
2. Illustrate 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. 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.
5. 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.
6. Exhibit skills to analyse obtained results and submit a technical report.

TECHNICAL CHEMISTRY

Course name	Technical Chemistry	Course credits	4.0
Course code	S3CHI02	L+T+P	3+0+2
Total No. of Contact Hours	Theory: 39 hrs Lab classes: 26 hrs		

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. **4 Hrs**

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. **4 Hrs**

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 Hrs**

UNIT – III

Nuclear Magnetic Resonance Spectroscopy: Principle of NMR spectroscopy. Energy levels for a nucleus with spin quantum number I = ½ and I = $^3/_2$. Theory of population of nuclear spin levels and chemical shift – definition, causes, measurement. TMS as a reference compound and its advantages, factors affecting chemical shift, shielding and deshielding mechanisms, correlation of chemical shifts with chemical environment – aliphatic, alkenic, alkynic, aldehydic, ketonic, aromatic, alcoholic, phenolic, carboxylic, amino

protons, spin – spin coupling, spin – spin splitting, intensity ratio of multiplet- Pascal's triangle method, chemical exchange, effect of deuteration, first order spectra, low and high resolution spectra, determination of peak areas, coupling constants-short and long range couplings, Instrumentation – FT NMR. Applications of electronic spectroscopy, IR and NMR to structural elucidation of simple organic molecules. **8 Hrs**

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.

vi) Rearrangement Reactions: Reaction of Reimer-Tiemann and Pinacol- pinacolone rearrangement. **8 Hrs**

UNIT – V

Chromatography: Introduction to Chromatography-Classification-Theory- Terminologies-distribution coefficient, retention time, retention factor, selectivity factor, column capacity, separation number, column efficiency, Types of Chromatography- adsorption, partition, ion exchange and size exclusion chromatography

Thin Layer Chromatography: Principle, mobile phase, sample application, development techniques – evaluation and documentation, advantages, limitations and applications

Gas Chromatography: Principle: Instrumentation, carrier gas, stationary phase, sample injection, columns,, detectors (TCD,FID)

High Performance Liquid Chromatography: Principle, instrumentation,

column, sample injection, detectors (absorbance, refractive index), mobile phase selection, applications.

Photochemistry: Introduction, significance of photochemistry, law governing light absorption, laws of photochemistry, electronic excitation, Jablonski diagram, photophysical process, supramolecular chemistry, surpamolecular photochemistry and introduction to optical sensors.

8 Hrs

Photochemistry: Introduction, Significancy of photochemistry, Laws Governing light absorption, Laws of photochemistry, Electronic excitation, Jablonski Diagram, photophysical process, supramolecular chemistry, supramolecular photochemistry and introduction to Optical Sensors. **7 Hrs**

Technical Chemistry Laboratory: 2Hrs/week

Identification and Estimation of physical parameters:

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 water sample 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 as ferric 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 materials characterization – (Demonstration of the experiment).

TEXTBOOKS:

R.M. Silverstein and W.P. Webster	Spectrometric Identification of Organic Compounds, Wiley & Sons, 1999, ISBN:978-9971514075.
Morrison B.R. and Boyd L.L.	Organic Chemistry, Pearson, New Delhi, 7e, 2010, ISBN:978-8131704813.

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
T. Riley and C. Tomilinsom	Principles of Electro analytical Methods, Wiley India Pvt. Ltd., 1e , 2011, ISBN – 978-8126532728
B. K. Sharma	Instrumental Methods of Chemical Analysis, Krishna Prakashan Media Pvt. Ltd., New Delhi, 1e, 2014, ISBN-978-8182836730
Peter Sykes	Organic Reaction Mechanism, ULBS Publishers, New Delhi, 1e ISBN: 978-8177584332
I L Finar	Organic Chemistry, Vol. 1 & 2, ULBS Publishers, New Delhi, ISBN: 978-8177585421 & ISBN: 978-8177585414
Thivari Melhrotra & Vishnoi	Organic Chemistry, Chand S Compay, New Delhi, 7e, 1996, ISBN: 978-9385879128
Arun Bahal & Bahal BS	Text Book of Organic Chemistry, Chand S Compay, New Delhi, 1998,

ISBN: 978-9352531967

Shikha Agarwal — Engineering Chemistry Fundamental and Applications, Cambridge University Press, UK, 2e, 2019, ISBN:978- 1108579209

Arthur I. Vogel, — Quantitative Inorganic Analysis and Elementary Instrumental Analysis, ELBS, Longmann Group, 5e, 1989, ISBN:0-582-44693-7.

Course Outcomes: On successful completion of this course, the graduate will be able to:

1. 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
2. Predict about different kinds of reactive intermediates, involved in a reaction.
3. Identify the analyte present in the mixture by applying principles of chromatography and optical properties of the material by photochemistry technique.
4. Estimate organic compound present in a solution by adopting standard methods
5. Demonstrate skills to use analytical instruments, to estimate chemical and physical parameters of a solution/mixture.
6. Exhibit skill to analyze obtained results, validate and submit a technical report.

PROCESS CALCULATIONS

Course name	Process Calculations	Course credits	3.0
Course code	S3CH01	L+T+P	2+2+0
Total No. of Contact Hours	Theory:26 hrs Tutorials:26 hrs		

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. Learn the 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

Basic chemical calculations: Concepts of mole, mole fraction; compositions of mixtures of solids, liquids and gases; concepts of normality, molarity, molality, ppm; use of semi-log, log-log and triangular graphs. **5+5 Hrs**

Unit - II

Material balance without reaction: General material balance equation for steady state operations. Typical steady state material balances in distillation, absorption, extraction, crystallization, drying, mixing and evaporation. **5+5 Hrs**

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. **5+5 Hrs**

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. **5+5 Hrs**

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 HF 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. **5+7 Hrs**

TEXTBOOKS:

Narayanan, K.V and Lakshmikutty, B	Stoichiometry and Process Calculations, PHI Learning Pvt. Ltd., Connaught Circus, New Delhi, 2e, 2016, ISBN: 978-8120352896
Himmelblau, D.M., and Riggs, J.B	Basic Principles and Calculations in Chemical Engineering, PHI Learning Pvt. Ltd., Connaught Circus, New Delhi, 2014, 8e, ISBN: 978-81-325-4962-3
B I Bhatt and S B Thokore	Stoichiometry, McGraw Hill, 5e, 2017, ISBN:978-0-07-068114-9

REFERENCE BOOK:

Felder, R.M. and Rousseau R.W	Elementary Principles of Chemical Processes, Wiley India (P.) Ltd., New Delhi, 3e , 2008, ISBN: 978-81-265-1582-0

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

1. Demonstrate the knowledge of calculations in chemistry, physics, and mathematics and apply them to solve basic chemical engineering unit operations and processes.
2. Analyze problems related to process calculations and provide conclusions using the first principles of gas laws, phase equilibria, material and energy balance.
3. Develop solutions to basic and complex process calculations problems.
4. Communicate the solutions to process calculations problems effectively in both oral and written form.
5. Demonstrate the ability of identify, analyze and solve process calculation problems individually and in a team.

COMPUTER AIDED EQUIPMENT DRAWING

Course name	Computer Aided Machine Drawing	Course credits	1.0
Course code	S3CHL01	L+T+P	0+0+2
Total No. of labs / semester	Lab classes: 26 Hrs		

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 assembly 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: equipment symbols important equipment symbols, piping symbol and pipe joints, proportionate drawings of some parts of equipments. proportionate drawings of some common equipments

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. (Any one of the above)

TEXTBOOKS:

K R Gopal Krishna	Machine Drawing, Subhas Stores, Bangalore, 9e, 1995,
Bhatt N.D.	Machine Drawing, Charotar Publishing House, Anand, 50e, 2014, ISBN: 978-9385039232

REFERENCE BOOK:

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

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

1. Demonstrate knowledge about the engineering graphics and adoption of the same in Computer Aided Drawing (CAD) as tool for drawing.
2. Draw the precise engineering drawings and represent the same systematically adopting the standard conventions.
3. Develop views of simple elements and piping symbols using CAD tool
4. Demonstrate practical skills to generate 3D models of the simple and elemental parts of the assembly .
5. Generate3D model of assembly for easier Comprehension and effective communication.

MATERIAL SCIENCE AND ENGINEERING

Course name	Material Science and Engineering	Course credits	3.0
Course code	S3ESC11	L+T+P	3+0+0
Total No. of Contact Hours	Theory: 39 hrs		

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

Introduction: Introduction to material science, classification of engineering materials, Level of structure, Structure property relationships in materials.

Phase Diagram and Phase Transformations: Phase rule, Single

component systems, Binary phase diagrams, Lever rule, Typical phase diagrams for Magnesia-Alumina, Copper-Zinc, Iron – Carbon systems, Nucleation and growth, solidification, Allotropic transformation, Cooling curve for pure iron, Iron-carbon equilibrium diagram, Isothermal transformations (TTT Curves).

8 Hrs

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 Hrs

UNIT – III

Typical Engineering Materials: Ferrous metals, Non ferrous metals and alloys – Aluminum and its alloys, Copper and its alloys, Lead and its alloys, Tin, Zinc and its alloys, Alloys for high temperature service, Ceramic materials, Mechanical, electrical and thermal properties of ceramic phase, Refractories, Glasses, Abrasives. Organic materials, Organic protective coatings. **8 Hrs**

UNIT – IV

Nano Materials: Classification, synthesis, characterisation and application of Nano materials – Fullerenes, Buckyballs, carbon nano tubes, fullerites. Applications of Nano materials. **7 Hrs**

UNIT – V

Advanced Materials: composite materials, definition, classification, types of matrix materials and reinforcements, fundamentals of production of FRP's and MMC's, advantages and applications of composites.

Smart Materials : Introduction, classification, definition of each type of smart material. **8 Hrs**

TEXTBOOKS:

Raghavan V	"Materials Science and Engineering - A First Course", Prentice Hall of India. New Delhi, 3e, 2015, ISBN: 978-8120350922
Charles P Poole, Frank J Owens	"Introduction to Nanotechnology", John Wiley & Sons, 1e, 2007, ISBN: 978-8126510993

REFERENCE BOOKS:

Van Vlack H.L. "Elements of Materials Science", Addison –Wesley Publishing Company, New York, 2e, 2002, ISBN: 978-8131706008

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

Course Outcomes: After completion of this course, students will be able to:

1. Apply the knowledge of materials engineering fundamentals, phase transformations, transformation curves, and different heat treatment methods to materials development.
2. Identify, formulate, and analyze materials processing problems in nucleation and crystal growth through TTT and CCT curves.
3. Select appropriate material for a given application.
4. Demonstrate the knowledge of nanomaterials processing, principles, and methods.
5. Illustrate about composite and advanced materials and their applications

INTRODUCTION TO POLYMER SCIENCE AND TECHNOLOGY

Course name	Introduction to Polymer science and Technology	Course credits	3.0
Course code	S3ESC12	L+T+P	3+0+0
Total No. of Contact Hours	Theory:39 hrs		

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 Hrs**

Unit-II

Synthesis of polymers: Step growth polymerization**:** Molecular-weight in step-growth polymerization, Step growth polymerization kinetics.

Chain-Growth polymerization: Free-Radical Polymerization and Copolymerization, Ionic Polymerization and Copolymerization, Coordination Polymerization, Controlled Radical Polymerizations.

Chemical structure determination: Vibrational Spectroscopy, Nuclear Magnetic Resonance Spectroscopy

Unit-III

Conformation, Solution, and Molecular Weight: Polymer Conformation and 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 Hrs**

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 Hrs**

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 Hrs**

TextBooks:

Fried J R Polymer Science and Technology, Prentice Hall of India Pvt. Ltd., New Delhi, 2e, 2005, ISBN:978-8129709097.

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

Reference Book:

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

Course Outcomes: This course will enable students to:

1. Illustrate the structure and classification of polymers.
2. Choose appropriate polymer synthesis method and characterization techniques
3. Identify the appropriate material for the engineering applications.
4. Suggest suitable technique for the polymer degradation.

INTRODUCTION TO CHEMICALS FROM BIOMASS

Course name	Introduction to Chemicals from Biomass	Course credits	3.0
Course code	S3ESC13	L+T+P	3+0+0
Total No. of Contact Hours	Theory:39 hrs		

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 Hrs**

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 Hrs**

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 Hrs**

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 Hrs**

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 Hrs**

TextBook:

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:

Klass, D. L	Biomass for Renewable energy, fuels and chemicals, Academic Press UK, 1e, 1998, ISBN: 978-0-12-410950-6
Hornung A	Transformation of Biomass- Theory and Practice, John Wiley & Sons Ltd., UK, 1e, 2014, ISBN: 978-1-119-97327-0
Brown R. C., Ed.,	Thermo chemical Processing of Biomass, John Wiley & Ltd., UK, 1e, 2011, ISBN:978-0-470-72111-7

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

1. Demonstrate the knowledge of biomass as a resource to derive various chemical product
2. Choose suitable treatment methods for deriving products from biomass
3. Identify technology for obtaining platform molecule
4. Choose a efficient methods for deriving various chemicals starting from biomass.
5. Illustrate the role of biomass in developing new products chemicals for day to day application

CARBON SEQUESTRATION TECHNOLOGY

Course name	Carbon Sequestration Technology	Course credits	3.0
Course code	S3ESC14	L+T+P	3+0+0
Total No. of Contact Hours	Theory:39 hrs		

Course Objectives: This course will enable students to:

1. Introduce to the carbon cycle, capture and storage.
2. Acquaint with physical and 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 Hrs**

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 Hrs**

Unit III

Adsorption Capture System: Physical and Chemical fundamentals, adsorption process applications, adsorption technology RD & D status. **7 Hrs**

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 Hrs**

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. **8 Hrs**

TextBook:

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

Reference Book:

Rao Y.S., et al., Eds. Carbon Capture & Storage, ASCE Publications, 1e, 2015, ISBN:978-0-7844-1367-8

Berend Smit et al. Introduction to capture and sequestration, Imperial College Press, 1e, 2014, ISBN: 978-1-78326-827-1

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

1. Illustrate the carbon cycle and significance of carbon capture and storage.
2. Demonstrate knowledge about the principles beyond the physical and chemical absorption of carbon from industrial processes.
3. Suggest suitable adsorbent and type of adsorption capture system for carbon capture.
4. Illustrate the working principle and benefits of cryogenic process.
5. Differentiate geological and ocean storage methods along with their merits and demerits

SOCIAL CONNECT & RESPONSIBILITIES

Course name	Social Connect & Responsibilities	Course credits	1.0
Course code	S3UHV01	L+T+P	0:0:2:0
Total No. of Contact Hours	26	CIE Marks	50

Course Objectives: This course will enable students to:

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 Hrs**

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 and documentary on evolution and practice of various craft forms. **6 Hrs**

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 of organic farming, Basic steps in organic farming and limitations of organic farming. **4 Hrs**

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 Hrs**

Unit V

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

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

1. Understand social responsibility
2. Practice sustainability and creativity
3. Showcase planning and organizational skills

BASIC LABORATORY PRACTICES AND DATA ANALYSIS

Course name	Basic Laboratory Practices and Data Analysis	Course credits	1.0
Course code	S3AECO1	L+T+P	0+0+2
Total No. of Contact Hours	Lab classes: 26 hrs		

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)

Practical Exercises on Data analysis:

1. Curve fitting using linear regression analysis (analytical) (2 h)
2. Curve fitting using non-linear regression analysis (analytical) (2 h)
3. Curve fitting using linear regression analysis using MS Excel (2 h)
4. Curve fitting using non-linear regression analysis using MS Excel (2 h)

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)

TEXTBOOKS

1 Pauline M. Doran Bioprocess Engineering Principles, 2e, 2013, ISBN: 978-0-12-220851-5

Student 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 the student will be able to:

1. Classify basic science and engineering data and related errors and apply them to solve basic engineering calculations and problems.

2. Analyze basic science and engineering data and provide conclusions.
3. Apply computational techniques (MS Excel) for data analysis and to solve complex mathematical functions.
4. Communicate basic science and engineering data using MS Office in oral and written forms.
5. Demonstrate basic chemical laboratory skills with an emphasis on safety and good laboratory practices.

MATERIAL SELECTION FOR MECHANICAL DESIGN

Course name	Material Selection for Mechanical design	Course credits	1.0
Course code	S3AECO3	L+T+P	1+0+0
Total No. of Contact Hours	Theory classes: 15 hrs		

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 Hrs**

Unit II

Classification of engineering material based on its properties. Reading and understanding various charts for selection of material. **3 Hrs**

Unit III

The selection strategy, deriving property limits and material indices. The selection procedure and structural index. **3 Hrs**

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 Hrs**

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 Hrs**

TextBook:

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

Reference Book:

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

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

1. Illustrate knowledge about materials and their classification for design and selection.
2. Demonstrate usage of material data charts.
3. Illustrate about various methods of material processing and their design.
4. Identification of appropriate materials under given constraints.
5. Select suitable data source for selecting materials for design.

PYTHON PROGRAMMING LABORATORY

Course name	Python Programming Laboratory	Course credits	1.0
Course code	S3AECO2	L+T+P	0+0+2
Total No. of Contact Hours	Lab Classes: 26 hrs		

Course objectives: This course will enable students to:

1. Learn basic aspects of python programming.
2. Learn various functions associated with python program.
3. Learn to work with files operation and classes.
4. Learn to use JSON and other file format.

List of Experiments:

1. Programs on basic concepts of python.
2. Programs on Strings.
3. Programs on lists, tuples and dictionaries.

4. Programs on regular expressions.
5. Programs on exception handling.
6. Programs on files operations.
7. Programs on classes and objects.
8. Programs on web-scrapping
9. Programs to work with CSV.
10. Programs to work with JSON and other file formats.

TextBook:

Al Sweigart	Automate the Boring Stuff with Python, No Starch Press, 1e, 2015, ISBN: 978-1593279929

Reference Books:

Gowrishankar S and Veena A	Introduction to Python Programming, CRC Press / Taylor and Francis, 1e, 2018, ISBN: 978-0367400179
Charles Dierbash	Introduction to Computer Science with Python, Wiley India Pvt. Ltd. 1e, 2015, ISBN: 978-8126556014

Course outcomes: By the end of the course the students will be able to:

1. Apply basic aspects to write simple program.
2. Make use of Python functions to solve chemical Engg. Problem.
3. Demonstrate the usage of files operation and classes to address chemical Engg. Operation.
4. Develop python program to solve Chemical Engineering problem using JSON and other file format.

CHEMICAL ENGINEERING THERMODYNAMICS

Course name	Chemical Engineering Thermodynamics	Course credits	3.0
Course code	S4CH01	L+T+P	3+0+0
Total No. of Contact Hours	Theory: 39 hrs		

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 to 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 Hrs

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 Hrs

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 Hrs

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 Hrs**

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 Hrs**

TEXTBOOKS:

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

REFERENCEBOOKS:

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

Course Outcomes: After the completion of the course, the student will be able:

1. Illustrate the role of role of thermodynamics and apply the laws of thermodynamics to obtain solutions to basic problems related to chemical industry.
2. Demonstrate knowledge about the P-V-T behavior of systems, Equation of States and Compressibility coefficient and their applications in engineering.
3. Apply the concepts related to thermodynamic properties of solutions to analyse engineering problems.
4. Illustrate concepts of the phase equilibrium & and its significance in unit operations.
5. Apply the concept of Chemical Equilibrium, and estimation of yield of a given type of reaction.

PROCESS HEAT TRANSFER

Course name	Process Heat Transfer	Course credits	4.0
Course code	S4CHI01	L+T+P	2+2+2
Total No. of Contact Hours	Theory: 26 hrs Tutorials: 26 hrs Lab classes: 26 hrs		

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.
6. Learn about radiation heat transfer between different surfaces.
7. Acquaint with the design of heat transfer equipment such as double pipe heat exchanger, shell & tube heat exchanger and evaporators and evaluate their performance.
8. Determine the rate of heat transfer by conduction, convection, and radiation by conducting various experiments

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.

6+6 Hrs

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. **5+6 Hrs**

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. **6 +5 Hrs**

Unit – IV

Heat Transfer Equipments: Double pipe heat exchanger. Shell and tube heat exchangers, Condensers, Construction details.

Evaporators: Classification of evaporators, Capacity, Economy, boiling point elevation, heat transfer area of evaporator, Methods of feeding, Vapor recompression evaporators.

5 +6 Hrs

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.

4 + 3 Hrs

TEXTBOOKS:

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

REFERENCE BOOKS:

McCabe and Smith W.L	Unit Operations of Chemical Engineering, McGraw Hill, New York,7e, 2007, ISBN: 978-007118173
Coulson J.M and Richardson J.F	Chemical Engineering,Vol.1, Asian Books, New Delhi, 6e, ISBN:978-81847368.
Kern D.Q	Process Heat Transfer, McGraw Hill, New York, 1e, 2017, ISBN:978-0074632178
Rao Y.V.C	Heat Transfer, Universities Press (India) Ltd., New Delhi, 1e, 2010, ISBN:9780072848236
James Welty, Gregory L. Rorrer, et al.	Fundamentals of Momentum Heat and Mass Transfer, Wiley Publications; 7e, 2020, ISBN: 978-1119723547
Yunus A. Cengel & Afshin J. Ghajar	Heat and Mass Transfer - Fundamentals and Applications, McGraw Hill Publication, 6e, 2020, ISBN: 978- 9390185283

Process Heat Transfer Laboratory: 2 Hrs/week
The experiments are based on the following topics.

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 coefficient in spiral plate heat exchanger
5. Estimation of overall heat transfer coefficient in packed bed heat transfer and verification of correlations
6. Estimation of overall heat transfer coefficient and draw Wilson plot for a vertical condenser
7. Estimate individual and overall heat transfer coefficient in a shell and tube condenser
8. To determine the overall heat transfer coefficient and critical radius of insulation
9. Thermal conductivity of insulating powder
10. Overall heat transfer coefficient of a plate heat exchanger.

Course Outcomes: On successful completion of the course, the student will be able to:

1. Apply the concepts of conduction to determine steady-state unidirectional rate of heat transfer through different geometries.
2. Design insulation and fins for effective heat transfer.
3. Develop equations for convection and apply them to solve problems.
4. Design heat transfer equipments and evaporators and evaluate their performance.
5. Solve problems on radiation using the laws of radiation.

MECHANICAL OPERATIONS

Course name	Mechanical Operations	Course credits	4.0
Course code	S4CHI02	L+T+P	2+2+2
Total No. of Contact Hours	Theory: 26 hrs Tutorials: 26 hrs Lab classes: 26 hrs		

Course objectives This course will enable students to:

1. Introduce to the basic principles of mechanical operations such as particle size, particle size distribution, particle size measurement, estimation of average particle size a by screening technique.

2. Learn about principles of size reduction, laws of size reduction and different types of equipment for size reduction like crushers and grinders
3. Introduce to the concepts and laws governing flow past immersed bodies, principles of fluidization and concepts about settling
4. Learn about construction and working of sedimentation devices, principles of filtration, different devices of filtration used in industry.
5. Acquaint with the principles of liquid mixing, components of an agitated vessel, estimation of power consumption in an agitated vessel under given conditions, solid-solid mixing devices and conveyors application in industry
6. Acquire practical skill in separation of particles of a given solid mixture by screening technique, estimate power required for crushing, and separation of solid-liquid mixture, application of flow past immersed bodies
7. Acquire practical skills to estimate the performance of size reduction, filtration and sedimentation devices, etc.

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.

6+6 Hrs

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.

6+6 Hrs

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. **6+6 Hrs**

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. **5+3 Hrs**

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. **3+5 Hrs**

Mechanical Operations Laboratory: 2Hrs/week

The experiments are based on the following topics:

1. To determine the specific surface area of a given sample power using Air Permeability setup.
2. To find the new surface area created for a given sample using Ball Mill and to find its critical speed.
3. To carry out batch sedimentation test and design the area required to handle for given slurry.
4. To find the particle size distribution and the average size of sub-sieve particle by beaker decantation method.
5. To find the drag co-efficient exerted on a given spiracle particle and verify the laws of settling.
6. To demine the crushing law constants and work index for crushing a known sample using drop weight crusher.
7. To demine the crushing law constants and work index for crushing a known sample using jaw crusher.
8. To determine specific cake resistance and filter medium resistance during filtration for a given sample using leaf filter.
9. To determine specific cake resistance and filter medium

resistance during filtration for a given sample using plate and frame filter press.

10. To determine the screen effectiveness and the ratio of over flow/feed and under/flow/feed for a given sample.
11. To determine pressure drop per unit bed length in fluidized bed
12. To verify the relationship between the velocity of the fluid and pressure drop per unit length of packing in a packed bed.

TEXTBOOKS:

McCabe W.L., Julian C Smith, Peter Harriott	Unit Operations of Chemical Engineering, McGraw Hill International. Singapore, 7e, 2017, ISBN: 978-9339213237.
Badger W.L. and Banchero J.T	Introduction to Chemical Engineering, McGraw Hill International Edition, Singapore, 1e, 2017, ISBN: 978-0074630501

REFERNCE BOOKS:

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

Course outcomes: On successful completion of the course, the student will be able to:

1. Demonstrate knowledge about the basic principles of mechanical operations such as particle size, particle size distribution, particle size measurement, estimation of average particle size a by screening technique.
2. Illustrate about principles of size reduction, laws of size reduction and different types of equipment for size reduction like crushers and grinders
3. Analyse the various laws governing flow past immersed bodies, and obtain solutions for problems based of fluidization and settling principles
4. Illustrate about construction and working of sedimentation devices, principles of filtration, different devices of filtration used in industry.

5. Illustrate the principles of liquid mixing, components of an agitated vessel, estimation of power consumption in an agitated vessel under given conditions, solid-solid mixing devices and conveyors application in industry
6. Demonstrate practical skill in separation of particles of a given solid mixture by screening technique, estimate power required for crushing, and separation of solid-liquid mixture, application of flow past immersed bodies
7. Demonstrate practical skills to estimate the performance of size reduction, filtration and sedimentation devices, etc.

COMPUTATIONAL METHODS FOR CHEMICAL ENGINEERING

Course Name	Computational Methods for Chemical Engineering	Course credits	1.0
Course Code	S4CHL01	L+T+P	0+0+2
Total No. of Lab Hours/ semester	Lab classes: 26 hrs		

Course Objectives: The course will enable the students to:

1. Familiarize the use of MATLAB as a computational tool for solving Chemical Engineering problems.
2. Learn to write programs for curve fitting, Linear and Nonlinear Equations to obtain desired solution
3. Acquaint with the concept and importance of Data Analysis and Statistics

List of experiments to be solved in MATLAB:

1. Interactive computation: Arrays, Vectors, and matrices
2. MATLAB files: Scripts and functions
3. Graphics with MATLAB
4. Solution of linear algebraic equations: Gauss elimination method, Gauss-Jordan
5. Solution of non-linear algebraic equations (single variable): Iterative methods - bisection, Newton –Raphson
6. Function Approximation: Least square curve fit
7. Ordinary Differential equations (Initial value problems): Euler method, Runge-Kutta method
8. Data Analysis
9. Data Regression
10. Numerical Integration
11. Course Project: A course project comprises of Chemical Engineering problem to gauge the understanding of the students.

TextBooks:

Rudra Pratap	Getting Started With MATLAB: A Quick Introduction for Scientists and Engineers, Oxford University Press, 1e, 2010, ISBN: 978-0198069195.
S.K. Gupta	Numerical Methods for Engineers, New Age International Publisher, New Delhi, 7e, 2003, ISBN: 978-8122406511.

Web Reference:
1. http://www.tutorialspoint.com/matlab/

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

1. Apply MATLAB software to solve simple numerical problems.
2. Develop and execute MATLAB programs to solve Chemical Engineering problems.
3. Analyse the results obtained from the MATLAB software.

UNIVERSAL HUMAN VALUES

Course Name: **Universal Human Values**		Course Code: NHS04	
Contact Hours / Week	1+0+0+0 (LTPS)	Credits :	1.0
Total Lecture Hours	13	CIE Marks :	50
Total Tutorial Hours	00	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 Hrs**

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 Hrs.**

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 Hrs.

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 Hrs.**

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 Hrs.

TextBook:

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 Book:

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

Web Resource:

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

https://www.youtube.com/watch?v=OgdNx0X923I

Course Outcomes: On successful completion of the course, the students will be able to

1. Become more aware of themselves, and their surroundings (family, society, nature)
2. Become more responsible in life, and value human relationships and human society

3. Have better critical ability in handling problems and in finding sustainable solutions

PETROLEUM REFINING TECHNOLOGY

Contact Hours/ Week	: 3+0+0 (L+T+P)	Credits :	3.0
Total Lecture Hours	: 39	CIE Marks :	50
Total Tutorial Hours	: 0	SEE Marks :	50
Sub. Code	: S4ESC11		

Course Objectives: This course will enable students to:

1. Introduce to the petroleum origin, theories of petroleum origin, characteristics of petroleum crude and products of petroleum and their characteristics.
2. Learn about various pre-treatment techniques adapted to crude oil, types of distillation adopted and products of distillation.
3. Introduce to specific properties essential for petroleum products and standard procedure for evaluation of the same.
4. Teach about the catalytic, non-catalytic processes for the production of petroleum products and reforming operation and its benefit in the industry

Unit – I

Composition of Crude: Origin and theory of formation of petroleum reserves and deposits of world. Overview of upstream and downstream operations. Composition of crude and classification of crude oil. Evaluation of petroleum, Over view of UOP-k factor, TBP analysis, EFV analysis, Average boiling point, ASTM in detail. Thermal properties of petroleum fractions.

7 Hrs

Unit – II

Crude Pre-treatment: Pumping of crude oils: Dehydration of crude by (1) Chemical, (2) Gravity, (3) Centrifugal and (4) Electrical Desalter and comparison of each.

Treatment Techniques: Types of impurities present, **Sweetening operations for gases:** Ethanolamine Treatment, Stretford Operation; Catalytic desulphurization; and Liquid SO2 extraction of aromatics.

8 Hrs

Unit – III

Products - Properties And Test Methods: Crude Distillation, Products from crude; Gasoline: ASTM Distillation, Reid Vapor Pressure Analysis, Octane Number, Oxidation stability, Additives; Kerosene: Flash point, Fire point, Smoke Point, Burning Quality; Diesel Fuels: Classification, Pour Point, Aniline Point, Viscosity, Additives for diesel; Lube Oils: Categories, Carbon Residue: Conradson Residue, Rams bottom Method and Bitumen: Softening Point, Penetration Index. **8 Hrs**

Unit – IV

Thermal Processes: Thermal cracking: Chemistry, theory, properties of cracked materials and factors influencing the properties of cracked materials, Visbreaking, Dubb's two coil cracking.

Coking: Types of coking processes, Dubb's two coil coking, delayed coking, fluid coking. **7 Hrs**

Unit – V

Catalytic Cracking: Catalytic cracking: Carbonium ion chemistry, catalysts, reaction variables; Fluid catalytic cracking - Texaco, ESSO, Kellog; Naphtha cracking; and Hydrocracking: Chemistry, catalysts, reaction conditions.

Catalytic Reforming: Chemistry, Reaction variables, catalysts, feedstock requirements. **8 Hrs**

TEXTBOOKS:

B Bhaskara Rao	Modern Petroleum Refining processes, Oxford & IBH Publishing, New Delhi, 6e, 2018, ISBN: 978-8120417151.
Ram Prasad	Petroleum Refining Technology, Khanna Publisher New Delhi, 2002, ISBN: 978-8174090645

REFERENCE BOOKS:

William Lyons, Gary J Plisga BS, Michael Lorenz, Eds	Standard Handbook of Petroleum and Natural Gas Engineering", Gulf Professional Publishing, 3e, 2015, ISBN: 978-0123838469
O. P. Gupta	Elements of Petroleum Refinery Engineering", Khanna Publishers, 1e, 2015, ISBN: 978-9382609728
Nelson WL	Petroleum Refinery Engineering", Mc. Graw Hill, USA 4e, 1958, ISBN:978-0070462687

Course Outcomes: After the completion of the course, the student will be able to

1. Discuss the origin and various characteristics of the crude
2. Describe crude various pretreatment techniques for crude.
3. Describe the characteristics and properties of selected products and its characterization
4. Demonstrate the knowledge of catalytic and non-catalytic processes for the production of petroleum products
5. Demonstrate the knowledge of reforming.

INDUSTRIAL SAFETY ENGINEERING

Contact Hours/ Week	3 (L)	Credits :	3.0
Total Lecture Hours	39	CIE Marks :	50
Total Tutorial Hours	---	SEE Marks:	50
Sub. Code	S4ESC12		

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. Lean about terminologies 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.
6. Introduce to the concepts of hazard identification as a preventive tool in enhancing industrial safety.

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 Hrs

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 Hrs

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 Hrs**

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 Hrs

Unit – V

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

5 Hrs

TEXTBOOKS:

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:

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

Course Outcomes: After the completion of the course, the student will be able:

1. Demonstrate the knowledge of the effects of toxic substances on humans organisms.
2. Identify, analyze, and recommend control measures for problems related to industrial hygiene.
3. Distinguish between fires and explosions and describe the methods for their prevention.
4. Identify and characterize reactive chemical hazards and outline methods for their control.
5. Explain the different hazard identification procedures.

DATA ANALYTICS

Course Code	S4ESC13	CIE Marks	50
Teaching Hours/Week (L:T:P)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	39	Total Marks	100
Credits	3	Exam Hours	2

Course objective: This course will enable students to:

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 Hrs**

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 Hrs**

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 Hrs

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.

8 Hrs

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 Hrs**

TEXTBOOK

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

REFERENCEBOOK

B. Dwarakanath, R. M. Rani, D. Usha,	Fundamentals of data science, Notion press, 2022, ISBN 9798885915717
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 out comes: At the end of the course, the student will be able to:

1. Appreciate the classification of data and using descriptive statistics for data handling.
2. Carry out multivariate data analysis and appreciate the quality of the data.
3. Use data clustering as a tool for efficient data mining.
4. Conduct data prediction, for predicting missing data. & understanding algorithm for predicting missing data.

PILOT PLANT AND SCALE UP METHODS

Course Code	S4ESC14	CIE Marks	50
Teaching Hours /Week (L:T:P)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	39	Total Marks	100
Credits	3	Exam Hours	2

Course Objectives: This course will enable students to

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 Hrs**

Unit II

Dimensional Analysis, Differential equation, Regime concept. **7 Hrs**

Unit III

Scale Up/down equation, extrapolation, boundary effects. **8 Hrs**

Unit IV

Scale up problem on transfer operation, momentum heat and Mass transfer. **8 Hrs**

Unit V

Scale up problems on mixing, agitated vessels and chemical reactors. **8 Hrs**

TextBooks:

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

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

1. Demonstrate knowledge the concept of pilot plant, model, prototype and similarity laws governing the scale-up method
2. Apply the dimensional analysis and differential equations in getting solutions to scaling up of process problems with constraints
3. Apply the similarity criterion to obtain solutions for scale up problems considering suitable types of regimes.
4. Solve problems of scale up related to unit operation equipment such as distillation column, evaporators, extraction, and absorption processes by adopting standard guidelines
5. Solve problems of scale up related to unit operation equipment and unit process equipment adopting standard guidelines.

BIOLOGY FOR ENGINEERS

Contact Hours/Week	3+0+0 (L+T+P)	Credits	3.0
Total Lecture Hours	40	CIE Marks	50
Course Code	N4CCA01	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 Hrs**

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 Hrs**

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 Hrs**

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 Hrs**

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 Hrs**

TextBooks:

Rajendra Singh C and Rathnakar Rao N, Rajendra Singh C	Biology for Engineers, Rathnakar Rao N Publishing, Bengaluru, 2023
Stuart Fox, Krista Rompolski	Human Physiology, McGraw-Hill eBook, 16e, 2022

Thyagarajan S., Selvamurugan N., et., al.,	Biology for Engineers, Tata McGraw-Hill, New Delhi, 2012.
Arthur T. Johnson	Biology for Engineers, CRC Press, Taylor and Francis, 2011, ISBN: 978-1420077636.
Leslie Cromwell et. al.	Biomedical Instrumentation and Measurements, Prentice Hall, 2e, 2015, ISBN: 978-8120306530.
Sohini Singh and Tanu Allen	Biology for Engineers, Vayu Education of India, New Delhi, 2014, ISBN: 978-1429834763.
Yoseph Bar-Cohen	Biomimetics: Nature-Based Innovation, 1e, 2012, CRC Press.
D. Floreano and C. Mattiussi	Bio-Inspired Artificial Intelligence: Theories, Methods and Technologies, MIT Press, 2023, ISBN: 0262547734
C R Sunilkumar, N Geetha A C Udayashankar	Bioremediation of heavy metals: bacterial participation, Lambert Academic Publishing, 2019
Ibrahim Ozbolat	3D Bioprinting: Fundamentals, Principles and Applications, Academic Press, 1e, 2016, ISBN: 978-0128030103.
Maria Laz Rodriguez Mende	Electronic Noses and Tongues in Food Science, Academic Press, 2016, ISBN: 978-0128002438.
E-Resources	https://nptel.ac.in/courses/121106008 https://freevideolectures.com/course/4877/nptel-biology-engineers-other-non-biologists https://ocw.mit.edu/courses/20-020-introduction-to-biological-engineering-design-spring-2009 https://ocw.mit.edu/courses/20-010j-introduction-to-bioengineering-be-010j-spring-2006 https://www.coursera.org/courses?query=biology https://onlinecourses.nptel.ac.in/noc19_ge31/preview https://www.classcentral.com/subject/biology https://www.futurelearn.com/courses/biology-basic-concepts

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

1. Elucidate the basic biological concepts via relevant industrial applications and case studies.
2. Evaluate the principles of design and development, for exploring novel bioengineering projects.
3. Corroborate the concepts of biomimetics for specific requirements.
4. Think critically towards exploring innovative biobased solutions for socially relevant problems.

INTRODUCTION TO PROCESS TECHNOLOGY

Contact Hours /Week	1+0+0 (L+T+P)	Credits	1.0
Total Lecture Hours	15	CIE Marks	50
Total Tutorial Hours	00	SEE Marks	50
Course Code	S4AEC11		

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 the 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 hrs**

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 hrs

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 hrs**

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 hrs**

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 hrs

Text Books:

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

Reference Books:

Charles E. Thomas Introduction to Process Technology, 3e, Cengage Learnring, USA, 2010, ISBN: 13-978-1-4354-5425-5.

Charles E. Thomas Process Technology and Equipment Systems, 4e, Cengage Learning, USA, 2015, ISBN: 978-1-285-44458-1

Course Outcomes: On successful completion of the course, the student will be able to:

1. Identify the various types of process diagrams and identify the various components through the symbols denoted on them.
2. Identity different types of pipes and valves by their symbols and regular maintenance schedules adopted in work place.
3. Identify different types of vessels and cooling towers and avoid the hazards associated with them in work place
4. Describe the various components of boiler their operation and maintenance
5. Describe about the various process auxiliaries and exhibit awareness about operational hazards and maintenance practices to be adopted in industry

WATER AND WASTE WATER CHARACTERIZATION

Contact Hours /Week	1+0+0 (L+T+P)	Credits	1.0
Total Lecture Hours	15	CIE Marks	50
Total Tutorial Hours	00	SEE Marks	50
Course Code	S4AEC12		

Course Objectives: This course will enable students to:

1. Introduce the types of pollutant, permissible concentration in different types of water and wastewater.
2. Learn about the physical, chemical and biological characteristics of water and wastewater.
3. Learn about the 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 Hrs**

Unit II

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

Unit III

Chemical characteristics: Organic compounds: BOD, COD, pH, Alkalinity, Acidity, Hardness, Dissolved Oxygen, Nitrogen content, Nitrate, Fluoride, Arsenic, Heavy metals, Pesticides, otherInorganic components and their determination. **3 Hrs**

Unit IV

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

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 usingJar test. **3 Hrs**

TEXTBOOKS:

Mark J. Hammer, Mark J. Hammer, Jr., "Water and Wastewater Technology", PHI Learning Private Ltd., New Delhi, 7e, 2012. ISBN: 9780135114049

Patwardhan, A.D "Industrial Waste Water Treatment", PHI learning, 2e, 2017, ISBN: 978-81- 203-3350-5

REFERENCE BOOKS:

Metcalf & Eddy "Wastewater Engineering Treatment and Reuse", McGraw Hill Education Private Ltd. NewYork, 5e, 2014, ISBN: 7-302-05857-1.

Eckenfelder, W.W "Industrial Water Pollution Control", McGraw-Hill, 1e, 2001, ISBN: 9780070393646.

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

Course Outcomes: On successful completion of the course students will be able to

1. Illustrate knowledge about water pollution, sources of pollution and their impact on environment, humans and other living beings.
2. Demonstrate knowledge about characteristics of waste water, standards for potable water and permissible limits of pollutants for various types of waste water.
3. Demonstrate knowledge about standard methods for estimation of important parameters of wastewater.

PROCESS ECONOMICS

Contact Hours / Week	:	1+0+0 (L+T+P)	Credits	:	1.0
Total Lecture Hours	:	15	CIE Marks	:	50
Total Tutorial Hours	:	00	SEE Marks	:	50
Course Code	:	S4AEC13			

Course Objectives: This course will enable students to:

1. Introduce to the concept of economics associated with process engineering design
2. Learn about various components of cost and its significance in engineering processes
3. Learn time value of money and other financial resources
4. Acquaint with various methods to calculate interest for a given principle amount
5. Learn about significance of types of depreciation for a project/equipment

Unit I

Introduction: Engineering Economics – An overview, relationship between engineering and economics, scope of engineering economics.

Process Design Development: Economics in the overall plant, plant location and layout – Factors affecting plant design and layout, economics of Plant location and layout. **3 Hrs**

Unit II

Estimating Component: Components of costs such as direct material cost, direct labour cost, fixed, Overheads, factory costs, administrative – Overheads, first cost, marginal cost, selling price, estimation for simple components.

3 Hrs

Unit III

Interest: Simple and compound interest, nominal and effective interest, continuous interest, interest formulae and their application, time value of money and numerical. **3 Hrs**

Unit IV

Comparison Methods for Rate of Interest: Present worth, future worth & annual Equivalent method of comparison, revenue and cash dominated cash flow diagram. **3 Hrs**

Unit V

Depreciation: Depreciation – Introduction, causes of depreciation, Methods of Depreciation - Straight Line method, Unit of Production Method, Double Declining Balance Method. **3 Hrs**

TEXTBOOKS:

M.S. Peters and K. D. Timmerhaus	Plant Design and Economics for Chemical Engineers", McGraw Hill, 5e, 2017, ISBN: 978-0071008716.
R Paneerselvam	"Engineering Economics", Prentice Hall India Learning Private Limited, 2e, 2013, ISBN: 978-8120348370.

REFERENCE BOOKS:

James Riggs	Engineering Economics", McGraw Hill Education, 4e, 2004, ISBN: 978-0070586703.
Prof. M.N. Vyas	"Management of Chemical Projects, Design and Economics", Atlantic Publishers and Distributors Pvt Ltd, 2020, ISBN: 978-8126931293.

Course Outcomes: On successful completion of the course students will be able to

1. Illustrate role of economics in project engineering and plant design
2. Estimate the cost of the process considering various components of accounting
3. Determine the time value of money for a given case
4. Select appropriate method to estimate the interest on financial resources sanctioned for a project
5. Estimate the depreciating value of the process assets

DATA ANALYTICS WITH EXCEL

Contact Hours / Week	:	0+0+2 (L+T+P)	Credits	:	1.0
Total Lecture Hours	:	15	CIE Marks	:	50
Total Tutorial Hours	:	00	SEE Marks	:	50
Course Code	:	S4AEC14			

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 Excercises:

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 Analyse 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. Analyse 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 Autofilter &macro.

TEXTBOOKS:

Manisha Nigam	Data Analysis with Excel, BPB Publications, New Delhi, 1e, 2019, ISBN: 978-9388176675.
Brain D Bissett	Automated Data Analysis using Excel, Chapmen and Hall/CRC Publications, USA, 1e, 2020, ISBN:978-0367509316

REFERENCE BOOKS:

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

Course outcomes: On successful completion of this course, students will be able :

1. Use advanced functions and productivity tools to assist in developing worksheets.
2. Manipulate data lists using Outline and PivotTables.
3. Use Consolidation to summarise and report results from multiple worksheets.
4. Apply Macros and Auto filter to solve the given real world scenario.