UNIVERSITY OF PETROLEUM & ENERGY STUDIES (UPES)

(ISO 9001:2008 Certified)

B. TECH. CHEMICAL ENGINEERING

w.e.f. 2022

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B.Tech. Chemical Engineering w.e.f. 2022

SEMESTER I			**SEMESTER II**		
Subject Code	**Subject**	**Credit**	**Subject Code**	**Subject**	**Credit**
SLLS 0101	Living Conversations	2	SLSG 0101	Critical Thinking and Writing	3
SLLS 0102	Learning how to learn	2	SLLS 0103	Leadership and Team Work	2
MATH1049	Engineering Mathematics I	4	CHCE 1001	Process Chemistry	4
PHYS1002	Physics	4	MATH 1051	Engineering Mathematics II	4
CSEG 1008	Object Oriented Programming	3	ECEG 1104	Basic Electrical and Electronics Engineering/Workshop Practices	2
ECEG 1004	Basic Electrical and Electronics Engineering	3	ECEG 1104	Basic Electrical and Electronics Engg Lab/Engineering Graphics	2
PRACTICAL			**PRACTICAL**		
CSEG 1108	Object Oriented Programming Lab	1	CHCE 1101	Process Chemistry Lab	1
MECH 1001	Basic Electrical and Electronics Engg Lab/Engineering Graphics	1			
PHYS1102	Physics Lab	1			
	TOTAL	**21**		**TOTAL**	**18**
SEMESTER III			**SEMESTER IV**		
Subject Code	**Subject**	**Credit**	**Subject Code**	**Subject**	**Credit**
	Exploratory 1	3	SLSG 0201	Ethical Leadership in the 21st century	3
SLLS 0201	Design Thinking	2	SLLS 0202	Working with data	2
CHCE 2010	Chemical Technology	3		Exploratory 2	3
CHCE 2025	Material and Energy Balance Computations	3	CHCE 2020	Mass Transfer I	4
CHCE 2003	Momentum Transfer	4	CHCE 2008	Chemical Engineering Thermodynamics II	4
CHCE 2002	Chemical Engineering Thermodynamics I	4	CHCE 2019	Numerical Methods in Chemical Engineering	4
SLLS 2001	Social Internship	0	SLLS 0202	Data Analytics and Machine Learning	3
CHCE 2021	Process Heat Transfer	4			
			PRACTICAL		
			CHCE 2103	Momentum Transfer Lab	1
				Heat Transfer Lab	1
	TOTAL	**23**		**TOTAL**	**25**
SEMESTER V			**SEMESTER VI**		
Subject Code	**Subject**	**Credit**	**Subject Code**	**Subject**	**Credit**
SLSG 0306	Environment and Sustainability-Himalaya Fellowship	3	SLSG 0301	Start your startup	3
SLLS 0301	Persuasive Presence	2		Exploratory 4	3
	Exploratory 3	3		Specialization Course II	3
	Specialization Course I	3	CHCE 3031	Chemical Reaction Engineering II	3
CHCE 3004	Chemical Reaction Engineering I	4	CHCE 3043	Process Equipment Design and Economics	3
CHCE 3029	Mass Transfer II	3	CHCE 3007	Process Dynamics, Instrumentation & Control	4
CHCE 2026	Particulate Technology	3	INDT 3105	Industrial Visit	0
			PROJ 3136	Minor Project	2
PRACTICAL			**PRACTICAL**		

CHCE 3105	Mass Transfer Lab	1	CHCE 3139	Chemical Reaction Engineering Lab	1
CHCE 3152	Particulate Technology Lab	1	CHCE 3149	Testing and Analysis Lab	1
	TOTAL	**23**		**TOTAL**	**22**
SEMESTER VII			**SEMESTER VIII**		
Subject Code	**Subject**	**Credits**	**Subject Code**	**Subject**	**Credits**
	Signature 5	3		Exploratory 6	3
	Exploratory 5	3		Signature 6	3
	Specialization Course III	3	PROJ 4110	Major Project 2	6
CHCE 4017	Transport Phenomena	4		Specialization Course IV	3
VIVA 4102	Comprehensive Viva	0			
INDT 4101	Industrial Internship	0			
PROJ 4101	Major Project 1	4			
PRACTICAL			**PRACTICAL**		
CHCE 4118	Design and Simulation Lab	2			
CHCE 4119	Instrumentation and Control Lab	1			
	TOTAL	**20**		**TOTAL**	**15**
Total Credits of B. Tech. Chemical Engineering with specialization in Refining & Petrochemicals 2022					**168**

Specialization Program Elective Courses

Specialization in Refining and Petrochemicals			**Specialization in Process Design and Intensification**		
Course Code	**Course**	**Credits**	**Course code**	**Course**	**Credits**
CHCE 3010P	Petroleum Refining Technology*	3	CHGS 3131P	Process Design and Intensification*	3
CHCE 3044P	Petrochemical Processing Technology*	3	CHGS 3132P	Process Modeling Simulation and Optimization*	3
CHCE 4025P	Catalyst Design and Catalysis	3	CHCE 4020P	Chemical Engineering Safety	3
CHCE 4020P	Chemical Engineering Safety	3	CHCE 4021P	Chemical Industry 4.0	3
CHCE 4024P	Chemical Process – by PCBL	3	CHCE 4024P	Chemical Process – by PCBL	3
Specialization in Clean Energy Technologies			**Specialization in Polymers and Specialty Chemicals**		
Course Code	**Course**	**Credits**	**Course code**	**Course**	**Credits**
EPEG 3041P	Energy Management System*	3	CHCE 3051P	Polymer Science, Processing and Applications*	3
EPEG 3040P	Renewable Energy Technologies*	3	CHCE 3046P	Specialty Chemicals*	3
CIVL 4072P	Sustainability Engineering	3	CHCE 4028P	Pharmaceutical Crystallization and Drug delivery	3
EPEG 4045P	Waste to Energy	3	CHCE 4029P	Industrial safety and hazard management	3
CHCE 4027P	Hydrogen Energy	3	CHCE 4024P	Chemical Process – by PCBL	3
CHCE 4024P	Chemical Process – by PCBL	3			

*Compulsory course

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 complexing 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, responsibilities, and norms of the engineering practice.

9. **Individual and teamwork**: 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, 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 engine**ering 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.

Program Specific Outcomes:

PSO 1: Design and operate unit processes and equipment of modern chemical, refining and petrochemical plant.

PSO 2: Solve practical chemical engineering problems using heat and mass conservation and transfer, reaction kinetics, thermodynamics, process control, economics and safety.

SEMESTER I

MATH1049	Engineering Mathematics I	L	T	P	C
		3	1	0	4
Pre-requisites/Exposure	Mathematics up to class XII				
Co-requisites					

Course Objectives:

1. To enable students to apply matrix theory in engineering problems.
2. To develop students' skills to apply the concept of differential and integral calculus in engineering problems.
3. To enables students to compute line and surface integral with the concept of vector calculus.
4. To enable students to compute Fourier series of periodic functions with convergent test of the series

Course Outcomes:

CO1. Find solution of a system of linear algebraic equations and canonical form of a quadratic form.
CO2. Discuss the power series representation of a function, functional dependency using Jacobian, and solution techniques of multiple integrals.
CO3. Demonstrate the basic concepts of vector calculus and principles of vector integration with relevant applications.
CO4. Discuss the tests of convergence of a series and the Fourier series representation of periodic function of a single variable.

Course Descriptions:

Mathematics is a necessary subject to a clear and complete understanding of virtually all phenomena. It helps us to develop logical thinking and also to find the right way to solve problems. This course covers Matrix theory, Differential calculus, Multiple integrals and Fourier series. This course is designed in such a way that it enables the students to cope confidently with the mathematics needed in their future subjects and the curriculum aims at developing student's ability to conceptualize, reason and to use mathematics to formulate and solve problems in their core subjects.

Course Curriculum:

Unit 1: Matrix - Elementary row and column operations, Inverse of a Matrix; Linear independence; Rank of a Matrix; Linear systems of equations, Gauss elimination, Gauss-Jordan elimination; Eigenvalues, Eigenvectors; Diagonalization of matrix; Cayley-Hamilton theorem; Orthogonal transformation and quadratic to canonical — 14 Hours

Unit 2: Differential and Integral Calculus - Successive Differentiation, Leibnitz Theorem, Expansion of functions of one variable by Taylor's and Maclaurin's series, Partial differentiation, Euler's theorem and its applications, Jacobian, Functional dependency; Double and triple integrals, change of order of integration, Change of variable. — 16 Hours

Unit 3: Vector Calculus - Vectors in 2-Space and 3-Space; Inner product (Dot product), Vector product (Cross product); Vector and scalar functions and fields, Derivatives; Curves. Arc length; Curvature; Gradient of a scalar field, Directional derivative; Divergence of a vector field; curl of a vector field. Line Integrals, Path Independence of Line Integrals; Green's Theorem in the Plane; Surface Integral. — 10 Hours

Unit 4: Fourier Series - Convergence of series, Tests for convergence; Fourier series: Half range sine and cosine series, Parseval's theorem. — 8 Hours

Text Books:

1. R. K. Jain and S. R. K. Iyengar, Advanced Engineering Mathematics, Narosa Publications. ISBN: 9788184875607.
2. E. Kreyszig, Advanced Engineering Mathematics, Wiley Publications. ISBN: 9788126531356.
3. B. V. Ramana, Higher Engineering Mathematics, Tata McGraw Hill. ISBN: 9780071070089.
4. B. S. Grewal, Higher Engineering Mathematics, Khanna publications. ISBN: 978-81-7409-195-5.

Reference Books:

1. M. D. Greenberg, Advanced Engineering Mathematics, Pearson Education, India. ISBN: 9788177585469.
2. S. Narayan, Differential Calculus, Shyamlal Charitable Trust, New Delhi. ISBN: 9788121904711.
3. N. Piskunov, Differential and Integral Calculus, CBS, New Delhi, India. ISBN: 8123904932.
4. J. Stewart, Essential Calculus: Early Transcendentals, Cengage Learning India Pvt. Ltd. ISBN: 8131503453.
5. D. G. Zill, Advanced Engineering Mathematics, Jones & Bartlett, India. ISBN: 9789384323271.

CO/PO Mapping for the course:

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	-	-	2	-	-	-	-	-	-	-	-	-
CO2	3	2	-	-	2	-	-	-	-	-	-	-	-	-
CO3	3	2	-	-	2	-	-	-	-	-	-	-	-	-
CO4	3	2	-	-	2	-	-	-	-	-	-	-	-	-
Avg	3	2	-	-	2	-	-	-	-	-	-	-	-	-

PHYS1002	Physics	L	T	P	C
		3	1	0	4
Pre-requisites/Exposure	12th Level Physics; 12th Level Mathematics				
Co-requisites	Mathematics I				

Course Objectives:

1. Understand the concepts of Interference, Diffraction and Polarization and apply these concepts in performing measurements using optical devices such as grating, Newton's rings, etc.
2. Understand the fundamentals of LASER and its use as a light source as well as its applications in optical fiber communication, holography and sensing.
3. Understand the properties of dielectrics and magnetic materials under the influence of electric and magnetic fields.
4. Construct a quantum mechanical model to explain the behavior of a system at the microscopic level.

Course Outcomes:

CO1. To recognize various optical phenomena such as interference, diffraction and polarization, and apply the knowledge in identifying and understanding optics-based devices such as lasers and its significance in optical fiber communication.
CO2. Understand the properties of dielectric and magnetic materials under the influence of electric and magnetic fields.
CO3. To apply the fundamentals of Quantum Mechanics to understand behavior of microscopic objects.

Course Descriptions:

Almost all disciplines of engineering and technology have origins in basic principles of physics. In this course we will try to address the one of the most fundamental question i.e. what is light? This question will be treated in both classical and quantum framework along with their implications as well as limitations. The wave nature of light as well as some of its important applications such as polarization, lasers, optical communication etc. will be studied in first unit. The second unit deals with very important class of engineering materials namely di-electric and magnetic materials along with their wide range of application. In third unit the focus will be to develop an understanding of the origin of transverse and longitudinal waves. In the last part of the course we will systematically study the development of 'modern physics', more specifically the quantum mechanics. The theoretical development of wave mechanics, their limitations, along with their contribution to revolutionize the modern world, will also be studied in the present course.

Course Curriculum:

Unit 1: Diffraction: Introduction to interference and example; concept of diffraction, Fraunhoffer and Fresnel Diffraction, Fraunhoffer diffraction at single slit and multiple slits; diffraction grating, characteristics of diffraction grating and its applications. 16 Hours

Polarization: Introduction Polarization by reflection, polarization by double refraction, scattering of light, circular and elliptical polarization, optical activity.

Fiber Optics: Introduction, Optical Fiber as a dielectric wave guide, total internal reflection, numerical aperture and various fiber parameters, losses associated with optical fibers, step index and graded index fibers, applications of optical fibers

Lasers: Introduction to interaction of radiation with matter, principle of working of laser: population inversion, pumping, population inversion, types of lasers, application of lasers

Unit 2: Laws of electrostatics, electric current and the continuity equation, laws of magnetism. Ampere's Faraday's laws. Maxwell's equations. Polarisation, permeability and dielectric constant, polar and non-polar dielectrics, internal fields in a solid, Clausius-Mossotti equation, applications of dielectrics. 16 Hours

Magnetisation, permeability and susceptibility, classification of magnetic materials, ferromagnetism, magnetic domains and hysteresis, applications.

Unit 3: Introduction to quantum physics, black body radiation, explanation using the photon concept, photoelectric effect, Compton effect, de Broglie hypothesis, wave-particle duality, Born's interpretation of the wave function, verification of matter waves, uncertainty principle, Schrodinger wave equation, particle in box, quantum harmonic oscillator, hydrogen atom. 16 Hours

Text Books:

1. Malik H.K, Singh A.K. (2011) Engineering Physics, TMH, New Delhi. ISBN: 9780070671539
2. Sadiku M.N.O. (2007) Elements of Electromagnetics, Oxford University Press. ISBN: 0195300483
3. Beiser A. (2002) Concepts of Modern Physics, McGraw Hill Education. ISBN: 9780070495531

Reference Books:

1. Griffith D.J. (2012) Introduction to Electromagnetics, PHI Learning, 4th edition, ISBN: 9780138053260
2. Ghatak A. (2012) Optics, McGraw Hill Education. ISBN: 978-1259004346

CO/PO Mapping for the course:

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	1	-	-	-	-	-	-	-	-	-	1	-	-
CO2	3	-	-	-	-	-	-	-	-	-	-	1	-	-
CO3	3	3	-	-	-	-	-	-	-	-	-	1	-	-
Avg	3	3	-	-	-	-	-	-	-	-	-	1	-	-

CSEG 1008	Object Oriented Programming	L	T	P	C
		3	0	0	3
Pre-requisites/Exposure	Fundamentals of Computer				
Co-requisites	Mathematics				

Course Objectives:

1. To help the students to understand and identify the functional units of a Computer System.
2. To enable students to understand the concepts of procedure-oriented programming using C Language.
3. To empower students with the expertise of experimentation using C programming skills.
4. To expose students with the ability to design programs involving decision structure, loops and functions.
5. To equip students with necessary engineering skills such as solving engineering problems through implementing concepts of arrays, pointers, structures and union in C programming language.

Course Outcomes:

CO1: Comprehend the fundamentals of Computers with concepts of algorithm, flowcharts and develop efficient algorithms for solving a problem.
CO2: Interpret the Control of flow statements and decision constructs with C programming techniques.
CO3: Identify the various concepts of Programming like Arrays, Structures and Unions and Strings.
CO4: Apply concepts of functions and pointers to resolve mathematical problems.
CO5: Analyze the real-life problem and write a program in 'C' language to solve the problem.

Course Descriptions:

Computer Programming is rapidly gaining the importance in the field of education and engineering. The course will introduce to the students about computer programming language and the fundamentals of computer programming. This subject is designed specifically for students with no prior programming experience and taking this course does not require a background in CS. This course will touch upon a variety of fundamental topics within the field of Computer Science and will use 'C' programming language to demonstrate varied principles. We will begin with an overview of the course topics as well as brief history of computers. We will cover basic programming terminology and concepts related to C language. By the end of the course, students should have a strong understanding of the fundamentals of C programming language. This course will help the students to build up a strong background in programming skills and a successful career devoted to implementing the principles they will learn. Students will learn effectively through prescribed syllabus as well as through blackboard and discussions. Classroom activities designed to encourage students to play an active role in the construction of their own knowledge. The students will be able to design their own learning strategies through online learning management system – Blackboard. We will combine traditional lectures with other active teaching methodologies, such as group discussions, cooperative group solving problems, etc. Class participation is a fundamental aspect of this course. Students will be encouraged to take part in all group activities to meet the course outcome. Students are expected to interact with media resources, such as, web sites, videos, DVDs, and newspapers, etc.

Course Curriculum:

Unit 1: Introduction – Generation and classification of computers, Basic computer organization, Number system (Binary, Octal, Decimal, Hexadecimal conversion problems), Need for logical analysis and thinking, Algorithm, pseudocode, flowchart. 7 Hours

Unit 2: C Programming Basics – Problem formulation, Problem Solving, Introduction to C Programming fundamentals, Structure of a C Program, Compilation and Linking processes, Constants, Variables, Data types – Expressions using operators in 'C', Managing input and output operations, 8 Hours

Decision making and branching, looping statements, solving simple scientific and statistical problems.

Unit 3: Arrays and Strings: Arrays – initialization, Declaration one dimension and two-dimensional arrays. String and string operations, string arrays, simple programs – sorting, searching, matrix operations. 7 Hours

Unit 4: Functions and Pointers – Functions – definition of function, Declaration of function, pass by value, Pass by reference, Recursion. Pointers – Definition, Initialization, Pointer's arithmetic, Pointers and arrays. 6 Hours

Unit 5: Structure and Union – Introduction - need for structure data type, Structure definition, Structure declaration, Structure within a structure, Array of Structures, Self-referential structure, notion of Linked List. Union, Storage class Specifiers, Preprocessor Directives, File Handling. 8 Hours

Text Books:

1. Thareja Reema, *"Computer Fundamentals & Programming in C"*, Oxford Press.
2. Kanetkar Yashwant, *"Let Us C"*, BPB Publications.

Reference Books:

1. Schildt Herbert, *"The Complete reference C"*.
2. Gottfried Byron, *"Programming with C"*, Schaum's Series.
3. Venugopal K.R. and Prasad S. R., *"Mastering 'C'"*
4. http://learn.upes.ac.in Blackboard – LMS

CO/PO Mapping for the course:

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	-	1	-	-	-	-	-	1	-	-	-
CO2	3	2	2	-	1	-	-	-	-	-	1	-	-	-
CO3	3	2	2	-	1	-	-	-	-	-	1	-	-	-
CO4	3	2	2	-	1	-	-	-	-	-	1	-	-	-
CO5	3	2	2	-	1	-	-	-	-	-	1	-	-	-
Avg	3	2	2	-	1	-	-	-	-	-	1	-	-	-

ECEG 1004	Basic Electrical and Electronics Engineering	L	T	P	C
		3	0	0	3
Pre-requisites/Exposure	Basic Knowledge of fundamentals of electrical components Engineering Mathematics				
Co-requisites					

Course Objectives:

1. The capability to design and construct circuits, take measurements of circuit behaviour and performance, compare with predicted circuit models and explain discrepancies.
2. To impart the basic knowledge about the Electric and Magnetic circuits.
3. To inculcate the understanding about the AC fundamentals and understand various Electrical Machines.
4. Employ electronic components and devices to solve the Engineering problems.
5. Analyse and make simple Circuits and Systems of Electronics Engineering, To Interpret the logics used in the Digital Circuits and Systems.
6. Design the electronics system with discrete component and to understand the specifications of industrial equipment.

Course Outcomes:

CO1: To understand various Electrical components and identify the importance of DC-theorem while solving any complex circuit
CO2: To understand the concepts of Electro magnetism and associated application on various Electrical Devices
CO3: To understand working principle and behavior of Electrical Machines.
CO4. Visualize the V-I characteristics of the basic electronic components like diode and transistor s
CO5. Develop the application-based circuits like switch, Rectifier by using Diode and transistor .and also by logic gates.
CO6. Design DC-Power supply by using Rectifiers and Adders& Subtractors by using Logic Gates.

Course Descriptions:

Electrical & Electronics is the integral part of life. The basic circuits used in day to day life are studied in this course. In this course, the main focus will be on the designing of basic electrical and electronics circuits like AC to DC converter by using diode, half adder, full adder etc. in Electronics and three phase system circuits in electrical. Students will learn how to use diode, transistor, Integrated circuit, AC machine and DC Machine in real time and develop circuits buy using them.
Classroom activities will be designed to encourage students to play an active role in the construction of their own knowledge and in the design of their own learning strategies. We will combine traditional lectures with other active teaching methodologies, such as practical sessions, group discussions, and cooperative group solving problems. Class participation is a fundamental aspect of this course. Students will be encouraged to actively take part in all practical sessions to apply the devices and design the basic circuits.

Course Curriculum:

Unit 1: Elements in an Electrical circuit: R, L, C, Diode, voltage and current sources	2 Hours
Unit 2: DC circuits, KCL, KVL, Network theorems, Mesh and nodal analysis	6 Hours
Unit 3: Step response in RL, RC, RLC circuits	2 Hours
Unit 4: Phasor analysis of AC circuits	6 Hours
Unit 5: Single-phase and 3-phase circuits.	2 Hours
Unit 6: Two port networks, BJT, CE and small signal model, operational amplifiers, model and applications.	2 Hours
Unit 7: Introduction to digital circuits	6 Hours
Unit 8: Transformers: modelling and analysis.	4 Hours
Unit 9: Energy in magnetic field.	2 Hours
Unit 10: Electromechanical energy conversion: principles and examples	2 Hours

Unit 11: Principles of measurement of voltage, current and power 2 Hours

Text Books:

1. Electrical & Electronics Engineering by K R Niazi,Genius Publication.ISBN:9788188870137
2. Basic Electrical and Electronics Engineering, by J B Gupta S K Kataria and Sons.3rd Ed.
3. Electronics Devices and Circuits By Boylestad & Nashelsky 10th ED: PEARSON: ISBN 978-8131727003

Reference Books:

1. Basic Electrical Engineering by Chakrabarti, Tata McGraw Hill. ISBN: 9781259083365
2. Basic Electrical Engineering byU.A.Bakshi, V.U.Bakshi, ISBN: 9788184316940
3. A Text Book of Electrical Machines by Rajput, L P Publications. ISBN: 9788131804469
4. Basic Electronics By Santiram Kal,(2013): PHI
5. Digital Circuits & Logic Design By Salivahanan: Vikas Publishing House. ISBN 978-9325960411

CO/PO Mapping for the course:

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	-	-	-	-	-	-	-	-	-	1	-	-
CO2	3	-	-	-	-	-	-	-	-	-	-	1	-	-
CO3	3	3	-	-	-	-	-	-	-	-	-	1	-	-
CO4	3	3	-	-	-	-	-	-	-	-	-	1	-	-
CO5	3	-	2	1	1							1	3	3
CO6	3	-	2	1	1							1	3	3
Avg	3	3	2	1	1							1	3	3

CSEG 1108	Object Oriented Programming Lab	L	T	P	C
		0	0	1	1
Pre-requisites/Exposure	Basic Knowledge of Computer Science such as fundamentals & logic for solving programs				
Co-requisites	Basic Knowledge of Mathematics.				

Course Objectives:

1. Able to understand basic computer fundamentals and functional units of computers with basic skills development in C Programming.

Course Outcomes:

CO1. Identify the functional units of computer system.
CO2. Understand the concepts of procedure-oriented programming using C.
CO3. Implement the basic concepts of C programming language.
CO4. Design programs involving decision structures, loops and functions.
CO5. Implement the concepts of arrays, pointers, structures in C programming language.

Course Descriptions:

Knowledge about the C programming knowledge is the building block of the students to build their programming skills. And enable the students to enhance the programming skills of the students and make them comfortable to adopt the new language for programming in future.

Experiment List:

Experiment No: 01 - Basic understanding of Linux/Unix commands.
Experiment No: 02 - Basics
Experiment No: 03 - Understanding and introduction to C programming
Experiment No: 04 - Control Statements using if.. if.. else, switch… case
Experiment No: 05 - Looping using while, do, while and for
Experiment No: 06 - Understanding and introduction Array
Experiment No: 07 - Understanding and introduction Strings
Experiment No: 08 - Understanding and introduction Functions
Experiment No: 09 - Understanding and introduction Pointers
Experiment No: 10 - Understanding and introduction Structure and union
Experiment No: 11 - Understanding and introduction File handling

Text Books:

1. Balagurusamy, E (2007), *ANSI C*, New Delhi: TMH
2. Introduction to Computers, Peter Norton, TMH, fifth Ed.
3. Programming in ANSI C, E Balaguruswamy, TMH

CO/PO Mapping for the course:

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	1	-	-	-	1	-	-	-	-	-	-	-	-
CO2	-	-	2	-	1	-	-	-	-	-	-	-	-	-
CO3	--	-	1	1	-	-	-	-	-	-	-	-	-	-
CO4	-	-	-	-	1	1	-	-	-	-	-	-	-	-
CO5	2	1	-	-	-	-	-	-	-	-	-	-	-	-
Avg	1.5	1	1.5	1	1	1	-	-	-	-	-	-	-	-

ECEG 1104	Basic Electrical and Electronics Engineering Lab	L	T	P	C
		0	0	1	1
Pre-requisites/Exposure	--				
Co-requisites	--				

Course Objectives:

1. To be able to apply the knowledge of basic electrical and electronics engineering to solve engineering problems

Course Outcomes:

CO1. Understand the objective of the experiment and experimental set-up/procedure of AC & DC circuits and Electrical machines
CO2. Compute the results of the experiments based on different fundamental theorems/laws.
CO3. Analyze and interpret the data obtained during experiments of Electrical circuits and electrical machine fundamentals

Course Descriptions:

The laboratory session deals with basic electrical and electronics engineering topics like LCR series and parallel circuits, DC machines, MC motors, MCB connections, ammeter, voltmeter, simple electrical circuits in order to provide hands on training to the students.

Experiment List:

1. To study Resistor Color Code, measuring the values using multimeter and ammeter voltmeter connection in simple electrical circuit.
2. To verify Thevenin's Theorem on Network Theorem kit.
3. To verify Superposition Theorem on Network Theorem kit.
4. To verify Maximum Power Transfer Theorem on Network Theorem kit.
5. Study the phenomenon of resonance in LCR series circuit.
6. Study the phenomenon of resonance in LCR parallel circuit.
7. To perform load test and calculate efficiency of single-phase transformer.
8. To study DC Machine working cut set model.
9. Speed control of DC Motor using armature and field control methods.
10. To study connection of MCB in electrical circuit and perform tripping action.

Text Books:

1. Theory and Problems of Basic Electrical Engineering by D. P. Kothari and I. J. Nagrath

CO/PO Mapping for the course:

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	1	2	-	1	-	-	-	-	-	-	-		
CO2	2	1	-	-	1	-	-	-	-	1	-	-		
CO3	1	2	1	3	3	1	-	1	-	2	-	1		
Avg	1.33	1.33	1	1	1.33	0.33	-	0.33	-	1	-	0.33	-	-

PHYS1102	Physics Lab	L	T	P	C
		0	0	1	1
Pre-requisites/Exposure	Basic knowledge on practical Physics (12th level) for understanding and performing experiments.				
Co-requisites	Data interpretation and basic knowledge on graphical analysis.				

Course Objectives:

1. To impart hand-on skills in performing experiments, data acquisition and interpretation of the data.
2. To design the circuits and study about various experimental procedures involved.
3. Significance of the experimental results to understand and verify theoretical formulation and prediction.
4. To develop curiosity and creative ability through experimentation and investigation based on the virtual experiments.

Course Outcomes:

CO1: Demonstrate the dual nature of light by verifying the various phenomena associated with it
CO2: Apply the concepts of electromagnetics to study the various electrical and magnetic properties of Materials.
CO3: Evaluate and compare the universal constants by using the principle of modern physics.
CO4: Design virtual Physics based experiments to illustrate the Photoelectric Effect.

Course Descriptions:

The laboratory practice has been an important part of professional and engineering undergraduate education, an ideal platform for active learning. The purpose of the Physics practical sessions is to give students hands-on experience with the experimental basis of engineering physics and, in the process, to deepen their understanding of the relations between experiment and theory. The focus of this course is to improve the skills of the students in collecting, analysing, interpreting and presenting findings and data.

Experiment List:

1. To study the Hall effect and hence determine the Hall coefficient (R_h) and carrier density (n) of a given semiconductor material.
2. To study the induced emf as a function of velocity of the magnet passing through the coil (Faraday's Law).
3. To study the charge delivered due to electromagnetic induction.
4. To study the variation of magnetic field with distance along the axis of a current carrying circular coil and hence estimate the radius of the coil.
5. To study the characteristics of photocurrent vs voltage at different frequency.
6. To determine the wavelength of a given light by forming Newton's Rings.
7. To determine the wavelength of a given light by using a Diffraction grating in its normal incidence position.
8. To determine the Numerical Aperture of an optical fibre and study about the bending losses.
9. To find the Planck's constant by using LEDs.
10. Presentation related to any science concept.

Text Books:

1. H. Singh, Practical Physics, S. Chand & Company LTD., ISBN: 8121904692.
2. S. L. Kakani, S. Kakani, Applied Physics-Theory & Practicals, Viva Books, ISBN: 9788130924892.
3. C. L. Arora, Practical Physics, S. Chand & Company LTD., ISBN: 9788121909099, 8121909090.

CO/PO Mapping for the course:

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	-	3	-	-	-	-	-	-	-	-	-	-	-	-
CO2	-	3	-	-	-	-	-	-	-	-	-	-	-	-
CO3	-	-	-	3	-	-	-	-	-	-	-	-	-	-
CO4	-	-	3	-	2	-	-	-	-	-	-	-	-	-
Avg	-	3	3	3	2	-	-	-	-	-	-	-	-	-

SEMESTER II

CHCE 1001	Process Chemistry	L	T	P	C
		3	1	0	4
Pre-requisites/Exposure	12th Level Chemistry				
Co-requisites					

Course Objectives:

1. To make students familiar with the fundamental concepts of chemistry.
2. To make the students understand the various basic chemical reactions, related calculations and reasoning.
3. To prepare the students for studying advanced subjects with required knowledge of chemistry.

Course Outcomes:

CO1. Choose and develop the appropriate fuel for commercial and domestic application with respect to socio-economic and environment concern.

CO2. Apply the concepts of reaction dynamics for the improvement of chemical reactions involved in general chemical processes.

CO3. Explain the mechanism, theories and preventive measurements, of corrosion, with the help of electrochemical concepts.

CO4. Analysis and enhance the water quality

CO5. Explain preparation method, properties and application of polymeric and nanomaterials.

Course Descriptions:

Chemistry is present everywhere around us. It is existing in everything we see, feel or imagine. It is one of the very fundamental basics behind every structure, building, bridge, refinery and industry. In this course, focus will be on firming the basic knowledge of students about chemistry. Students will learn how to use the concepts correctly through prescribed syllabus. They will be taught various types of fuels. Different processes used to improve the quality of fuels in refineries will be discussed. Combustion calculations related to oxygen or air required will help them to get an effective fuel: O2 ratio to result in proper and complete combustion. Water chemistry will make the students understand various parameters of water quality and the treatments to improve it. Chemical dynamics will help them to understand the mechanism of reaction. This knowledge will make them able to control the factors to move the reaction in desired direction. Corrosion is based on electrochemical cells. For any engineer, it is quite mandatory to have an understanding to select the suitable metal and also the methods to protect it from decaying. They will also be discussed about various types of polymers and nanomaterials so that they can correlate their properties to their various application areas.

Course Curriculum:

Unit 1: Fuels and Thermochemistry - Enthalpy of formation, Enthalpy of neutralization and Enthalpy of combustion, Hess's law of constant heat summation and its application, bond energy, Fuels - Introduction, Classification, Important properties of a good fuels, Calorific value, Determination of calorific value by Bomb calorimeter, Analysis of coal- proximate, Ultimate analysis, Combustion and its calculations, Distillation of crude oil, composition of petroleum, Important reactions for petroleum industries (isomerization, dimerization, aromatization, cracking), Octane number, cetane number, renewable energy sources: biodiesel, biogas, bioethanol. Hydrocarbons chemistry: Basic concepts for preparation strategy, chemical properties and reactivity of aliphatic (alkanes, alkenes, alkynes, cycloalkanes) and aromatic hydrocarbons — 10 Hours

Unit 2: Reaction Dynamics - Rate of reaction and rate constant, factors affecting rate of a reaction, order and molecularity of a reaction, Rate expression for zero and first order, Pseudo — 12 Hours

first order reaction, Second (2A & A+B) and third (3A) order reaction, Methods of determining order of a reaction: Hit and trial method, half-life period method, graphical method, Von't Hoff method (ratio variation method), differential method and Ostwald isolation method. Concept of energy barrier and activation energy, Collision theory, Kinetics of complex reactions- reversible, parallel, consecutive and chain reaction, Steady state approximation, Lindemann theory. Equilibrium and equilibrium constant, Kp, Kc, Kx. Homogeneous and heterogeneous equilibrium, Le-chatelier principle.

Unit 3: Electrochemistry and Corrosion - Galvanic cell, Single electrode potential, Nernst equation, Nernst Equation based concept and complex problem in electrochemistry, ECS and its applications. Conductance and its types, Variation of conductance with dilution, Kohlrausch law, conductometric titrations, application of electrochemistry in corrosion. Corrosion: Introduction, dry theory, Wet theory, acid theory, types, Factors, prevention. 8 Hours

Unit 4: Water Chemistry - Introduction, hardness of water, measurement of hardness, alkalinity, water softening- lime-soda process, zeolite process, ion exchange process. 8 Hours

Unit 5: Polymers - Classification, Types of polymerization techniques: Bulk, solution, suspension and emulsion, mechanism of polymerization (cationic, anionic and free radical), vulcanization, average molecular weight of polymers, conducting polymers, plastic used in daily life applications viz. making of tyres, ropes, electrical fittings, contact lenses, credit cards, air tight containers, cook-wares, cold drink bottles. 6 Hours

Unit 6: Nanomaterials - Introduction, Methods of preparation: precipitation, co-precipitation, sol-gel, hydrothermal, microemulsion. Introduction to various characterization techniques viz. XRD, SEM, TEM, BET, UV-VIS for nanomaterials. Properties: optical and surface properties. Application of nanomaterials. 4 Hours

Text Books:

1. Engineering Chemistry by Renu Bapna. Publisher: New Delhi: MacMillan, 2010, ISBN: 0230330762.
2. Text book of Engineering Chemistry by Shashi Chawla, Publisher: Delhi: Dhanpat Rai, 2014. ISBN 13: 123456755036.
3. Engineering Chemistry by P. Krishnamoorty. Publisher: New Delhi: McGraw Hill, 2012, Edition: 1. ISBN: 9780071328753.

Reference Books:

1. Encyclopedic dictionary of organic chemistry, By Milton, Jules K., Publisher: New Delhi Pentagon Press 2004 Description: 208 p., ISBN: 818274167--X; 9788182741676.
2. Crude oil chemistry, By: Simanzhenkov, Vasily, Book Publisher: New York: Marcel Dekker, 2003 Description: 409 p. ISBN: 082474098.
3. Atkins' physical chemistry, By: Atkins, Peter, Paula, Julio De, Book Publisher: New Delhi Oxford University Press 2014, Edition: 10th. ISBN: 9780198728726; 0198728727.
4. Essentials of Physical Chemistry by Bahl & Tuli, Publisher: S. Chand & Co., ISBN 13: 978-8121929783.
5. Organic Chemistry for engineers, By: Mallick, Abhijit, Book Publisher: New Delhi: Viva Books, 2012, ISBN: 9788130920580.

CO/PO Mapping for the course:

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	-	-	-	3	-	-	-	-	-	-	-	-	-
CO2	-	3	1	-		-	-	-	-	-	-	-	-	-
CO3	-	2	-	-	1	-	-	-	1	-	-	-	-	-
CO4	2	-	-	-	3	-	-	-	2	-	-	-	-	-
CO5	2	1	-	-	-	-	-	-	-	-	-	-	-	-

Avg	2	2	1	-	2.3	-	-	-	1.5	-	-	-	-	-

MATH 1051	**Engineering Mathematics II**	**L**	**T**	**P**	**C**
		3	**1**	**0**	**4**
Pre-requisites/Exposure	Mathematics I				
Co-requisites					

Course Objectives:

1. To enable the students to understand the basic concepts of differential equations.
2. To help the students develop the skills related to application of differential equations.
3. To enable students to understand the complex variables.
4. To make the students able to understand the applications of complex variables.

Course Outcomes:

CO1. Solve linear ordinary differential equations using various methods and comprehend the properties of Legendre polynomials and Bessel's functions.
CO2. Solve first order & linear second order partial differential equations and boundary value problems of linear PDEs in various geometries.
CO3. Illustrate the concepts of analyticity, integration of a complex function, conformal mapping, and series representation of a complex function.
CO4. Evaluate real integrals using calculus of residues

Course Descriptions:

Mathematics is a natural complementary discipline for learning, understanding and appreciating many fundamental computer science concepts. It helps us to develop logical thinking and also to find the right way to solve problems. The purpose of this course is to provide participants with the skills, knowledge required to perform fundamental mathematical procedures and processes for solution of engineering problems, particularly the use of differential equations (ordinary and partial), complex variables and complex functions. Continuous mathematics along with differential equations and complex variables is important foundation for engineering disciplines.

Course Curriculum:

Unit 1: Ordinary Differential Equations of Higher Order - Second order linear differential equations with constant coefficients by complementary function and particular integral method, Second order linear differential equations with variable coefficients, method of variation of parameters, Cauchy-Euler equation; Power series solutions; Legendre polynomials, Bessel functions of the first kind and their properties. — 14 Hours

Unit 2: Partial Differential Equations - First order partial differential equations, solutions of first order linear and non-linear PDEs, solution to homogenous and non-homogenous linear partial differential equations second and higher order by complementary function and particular integral method, Flows, vibrations and diffusions, second order linear equations and their classification, Initial and boundary conditions (with an informal description of well-posed problems), D'Alembert's solution of the wave equation; Duhamel's principle for one dimensional wave equation; Separation of variables method to simple problems in Cartesian coordinates; The Laplacian in plane, cylindrical and spherical polar coordinates, solutions with Bessel functions and Legendre functions; One dimensional diffusion equation and its solution by separation of variables; Boundary-value problems: Solution of boundary-value problems for various linear PDEs in various geometries. — 14 Hours

Unit 3: Complex Variables I - Differentiation, Cauchy-Riemann equations, analytic functions, harmonic functions, finding harmonic conjugate; Elementary analytic functions (exponential, trigonometric, logarithm) and their properties; Conformal mappings, Möbius transformations and their properties. 8 Hours

Unit 4: Complex Variables II - Contour integrals, Cauchy-Goursat theorem (without proof), Cauchy Integral formula (without proof), Liouville's theorem and Maximum-Modulus theorem (without proof); Taylor's series, zeros of analytic functions, singularities, Laurent's series; Residues, Cauchy Residue theorem (without proof), Evaluation of definite integral involving sine and cosine, Evaluation of certain improper integrals using the Bromwich contour. 12 Hours

Text Books:

1. Erwin Kreyszig, Advanced Engineering Mathematics, 9th Edition, John Wiley & Sons, 2006.
2. N.P. Bali and Manish Goyal, A text book of Engineering Mathematics, Laxmi Publications, Reprint, 2010.
3. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 35th Edition, 2000.

Reference Books:

1. S. L. Ross, Differential Equations, 3rd Ed., Wiley India, 1984.
2. W. E. Boyce and R. C. DiPrima, Elementary Differential Equations and Boundary Value Problems, 9th Edition, Wiley India, 2009.
3. E. A. Coddington, An Introduction to Ordinary Differential Equations, Prentice Hall India, 1995.
4. E. L. Ince, Ordinary Differential Equations, Dover Publications, 1958.
5. G.F. Simmons and S.G. Krantz, Differential Equations, Tata McGraw Hill, 2007.
6. S. J. Farlow, Partial Differential Equations for Scientists and Engineers, Dover Publications, 1993.
7. R. Haberman, Elementary Applied Partial Differential equations with Fourier Series and Boundary Value Problem, 4th Ed., Prentice Hall, 1998.
8. Ian Sneddon, Elements of Partial Differential Equations, McGraw Hill, 1964.
9. J. W. Brown and R. V. Churchill, Complex Variables and Applications, 7th Ed., Mc-Graw Hill, 2004.

CO/PO Mapping for the course:

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	-	-	1	-	-	-	-	1	-	-	-	-
CO2	3	2	-	-	1	-	-	-	-	1	-	-	-	-
CO3	3	2	-	-	1	-	-	-	-	1	-	-	-	-
CO4	3	2	-	-	1	-	-	-	-	1	-	-	-	-
Avg	3	2	-	-	1	-	-	-	-	1	-	-	-	-

MEPD 1001	**Workshop Technology**	**L**	**T**	**P**	**C**
		1	**0**	**1**	**2**
Pre-requisites/Exposure	Basic Knowledge of physics, chemistry & Mathematics				
Co-requisites					

Course Objectives:

1. This course aims at imparting knowledge and skill components in the field of basic workshop technology
2. It deals with different hand and machine tools required for manufacturing simple metal components and articles.
3. To impart the knowledge regarding the various basic manufacturing processes required in day to day life.
4. To familiarize the students with the properties and selection of different engineering material.

Course Outcomes:

CO1. Classify different materials according to their properties and application.
CO2. Explanation about the basic manufacturing process.
CO3. Illustrate the basic machine tools.
CO4. Classification of joining process
CO5. Explain carpentry process and its application

Course Descriptions:

Workshop technology is the backbone of the real industrial environment, which helps to develop and enhance relevant technical hand skills required by the engineers working in the various engineering industries and workshops. This course intends to impart basic expertise of various hand tools and their use in different sections of manufacturing. Irrespective of branch, the use of workshop practices in day-to-day industrial as well domestic life helps to dissolve the problems. The workshop experiences would help to build the understanding of the complexity of the industrial job, along with time and skills requirements of the job. The students are advised to undergo each skill experience with remembrance, understanding and application with special emphasis on attitude of enquiry to know why and how for the various instructions and practices imparted to them in each shop.

Course Curriculum:

Unit 1: Introduction to the course and its objectives; mandatory briefing on shop-floor safety. Introduction to all manufacturing forms, and introduction to basic tools (hand tools and power tools) — 4 Hour

Unit 2: Overview of engineering materials and forms in which they are commonly available as raw materials. Typical component manufacture with materials like wood. — 4 Hour

Unit 3: Overview of shape realization by manufacturing, measurement of manufactured parts. Associated with: Machine shop exercises- involving sawing, turning and drilling, milling, grinding and joining. Inspection of manufactured component using simple metrology instruments. — 10 Hour

Unit 4: Overview of computer numerically controlled machines Machine shop exercise using CNC - Part modeling, CNC program generation and cutting part on CNC milling machine — 4 Hour

Unit 5: Use of plastics and composites as engineering materials Practical: Hands-on exercise involving plastics - use of vacuum forming, injection/compression molding, extrusion, ultrasonic welding of plastic components etc. — 8 Hour

Text Books:

1. *Hajra Choudhury, S. K. and Hajra Choudhury, A. K. (2015) "Elements of Workshop Technology* Vol 1& Vol 2" Media Promoters & Publishers Pvt Ltd.
2. Khurmi, R. S. and Gupta, J. K. (2010) "Workshop Technology" S Chand Publisher

Reference Books:

1. Raghuvanshi, B. S. (2015) *"Workshop Technology Vol I &II"* –Dhanpat Rai & Publications Pvt Ltd
2. Kalpakjian, S. (2014) *"Manufacturing Engineering and Technology"* Pearson Publisher

CO/PO Mapping for the course:

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	-	-	-	-	-	-	-	-	-	-	3	-	-
CO2	3	-	-	-	-	-	-	-	-	-	-	3	-	-
CO3	3	-	-	-	-	-	-	-	-	-	-	3	-	-
CO4	3	-	-	-	-	-	-	-	-	-	-	3	-	-
CO5	3	-	2	-	2	2	3	-	-	-	-	3	-	-
Avg	3	-	2	-	2	2	3	-	-	-	-	3	-	-

MECH 1001	Engineering Graphics	L	T	P	C
		0	0	2	2
Pre-requisites/Exposure	--				
Co-requisites	--				

Course Objectives:

1. Introduction to engineering design and its place in society.
2. Exposure to the visual aspects of engineering design.
3. Exposure to engineering graphics standards.
4. Exposure to solid modelling.
5. Exposure to computer-aided geometric design.
6. Exposure to creating working drawings.
7. Exposure to engineering communication.

Course Outcomes:

CO1 Remember the conventions of engineering graphics such as types of lines, dimensioning, method of projection etc.

CO2 Demonstrate and communicate new ideas and design concepts through language of engineering graphics.

CO3 Apply principle of orthographic and isometric projections to represent basic layout of 3D product design and development and annotations on product drawing.

CO4 Analyze the basic Engineering drawings

Course Descriptions:

All phases of manufacturing or construction require the conversion of new ideas and design concepts into the basic line language of graphics. Therefore, there are many areas (civil, mechanical, electrical, architectural, and industrial) in which the skills of the CAD technicians play major roles in the design and development of new products or construction. Students prepare for actual work situations through practical training in a new state-of-the-art computer designed CAD laboratory using engineering software.

Course Curriculum:

Module 1: Introduction to Engineering Drawing - Principles of Engineering Graphics and their significance, usage of Drawing instruments, lettering, Conic sections including the Rectangular Hyperbola (General method only); Cycloid, Epicycloid, Hypocycloid and Involute; Scales – Plain, Diagonal and Vernier Scales; 5 Hours

Module 2: Orthographic Projections - Principles of Orthographic Projections-Conventions - Projections of Points and lines inclined to both planes; Projections of planes inclined Planes - Auxiliary Planes; 5 Hours

Module 3: Projections of Regular Solids - those inclined to both the Planes- Auxiliary Views; Draw simple annotation, dimensioning, and scale. Floor plans that include: windows, doors, and fixtures such as WC, bath, sink, shower, etc. 5 Hours

Module 4: Sections and Sectional Views of Right Angular Solids - Prism, Cylinder, Pyramid, Cone – Auxiliary Views; Development of surfaces of Right Regular Solids - Prism, Pyramid, Cylinder and Cone; Draw the sectional orthographic views of geometrical solids, objects from industry and dwellings (foundation to slab only) 5 Hours

Module 5: Isometric Projections covering - Principles of Isometric projection – Isometric Scale, Isometric Views, Conventions; Isometric Views of lines, Planes, Simple and compound Solids; Conversion of Isometric Views to Orthographic Views and Vice-versa, Conventions; 5 Hours

Module 6: Overview of Computer Graphics - listing the computer technologies that impact on graphical communication, Demonstrating knowledge of the theory of CAD software [such as: The 5 Hours

Menu System, Toolbars (Standard, Object Properties, Draw, Modify and Dimension), Drawing Area (Background, Crosshairs, Coordinate System), Dialog boxes and windows, Shortcut menus (Button Bars), The Command Line (where applicable), The Status Bar, Different methods of zoom as used in CAD, Select and erase objects.; Isometric Views of lines, Planes, Simple and compound Solids];

Module 7: Customization & CAD Drawing - consisting of set up of the drawing page and the printer, including scale settings, setting up of units and drawing limits; ISO and ANSI standards for coordinate dimensioning and tolerancing; Orthographic constraints, Snap to objects manually and automatically; Producing drawings by using various coordinate input entry methods to draw straight lines, Applying various ways of drawing circles; 6 Hours

Module 8: Annotations, layering & other functions - applying dimensions to objects, applying annotations to drawings; Setting up and use of Layers, layers to create drawings, Create, edit and use customized layers; Changing line lengths through modifying existing lines (extend/lengthen); Printing documents to paper using the print command; orthographic projection techniques; Drawing sectional views of composite right regular geometric solids and project the true shape of the sectioned surface; Drawing annotation, Computer-aided design (CAD) software modeling of parts and assemblies. Parametric and non-parametric solid, surface, and wireframe models. Part editing and two-dimensional documentation of models. Planar projection theory, including sketching of perspective, isometric, Multiview, auxiliary, and section views. Spatial visualization exercises. Dimensioning guidelines, tolerancing techniques; dimensioning and scale multi views of dwelling; 6 Hours

Module 9: Demonstration of a simple team design project - Geometry and topology of engineered components: creation of engineering models and their presentation in standard 2D blueprint form and as 3D wire-frame and shaded solids; meshed topologies for engineering analysis and tool-path generation for component manufacture; geometric dimensioning and tolerancing; Use of solid-modeling software for creating associative models at the component and assembly levels; floor plans that include: windows, doors, and fixtures such as WC, bath, sink, shower, etc. Applying color coding according to building drawing practice; Drawing sectional elevation showing foundation to ceiling; Introduction to Building Information Modelling (BIM). 6 Hours

Text Books:

1. Bhatt N.D., Panchal V.M. & Ingle P.R., (2014), Engineering Drawing, Charotar Publishing House
2. Shah, M.B. & Rana B.C. (2008), Engineering Drawing and Computer Graphics, Pearson Education
3. Agrawal B. & Agrawal C. M. (2012), Engineering Graphics, TMH Publication
4. Narayana, K.L. & P Kannaiah (2008), Text book on Engineering Drawing, Scitech Publishers
5. (Corresponding set of) CAD Software Theory and User Manuals

CO/PO Mapping for the course:

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO2	3	-	3	-	3	-	-	-	-	2	-	-	-	-
CO3	3	2	2	-	3	-	-	-	-	-	-	-	-	-
CO4	3	1	2	-	3	-	-	-	-	1	-	-	-	-
Avg	2.75	1.5	2.33	-	3	-	-	-	-	1.5	-	-	-	-

CHCE 1101	**Process Chemistry Lab**	**L**	**T**	**P**	**C**
		0	**0**	**1**	**1**
Pre-requisites/Exposure	Basic knowledge on practical Physics (12th level) for understanding and performing experiments.				
Co-requisites	Data interpretation and basic knowledge on graphical analysis.				

Course Objectives:

1. To help the students familiar with the fundamental concepts of practical chemistry
2. To make the students able to prepare standard solutions and few commercial materials
3. To make the students able to determine the strength of the solutions using basic instrumental and classical methods.

Course Outcomes:

CO1: Demonstrate the kinetics of chemical reaction and the synthesis of polymeric material like resins.
CO2: Analyze efficiency/quality of different fuels/water samples for commercial and domestic application.
CO3. Apply different types of titrations for various quantitative analysis.

Course Descriptions:

Chemistry is present everywhere around us. It is existing in everything we see, feel or imagine. It is one of the very fundamental basics behind every structure, building, bridge, refinery and industry. In this lab course, focus will be on firming the basic knowledge of students about chemistry. Students will learn how to use the concepts correctly through prescribed syllabus and will perform related experiments in the Chemistry lab. They will be taught to find the more effective fuel using proximate analysis and sulfur present in fuel through gravimetric analysis. fuels. Different processes used to improve the quality of fuels in refineries will be discussed. Water chemistry will make the students understand various parameters of water quality and the treatments to improve it. Kinetics experiments help them to find order of reaction in lab. They learn to prepare polymers also at lab scale. Lab activities include lab instructions, hands on experience, maintaining lab record and viva-voce.

Experiment List:

1. To determine the strength of given solution of NaOH by titrating it against standard oxalic acid solution using phenolphthalein.
2. To determine the percentage of moisture, volatile matter, ash content and fixed carbon in a given coal sample by proximate analysis.
3. To estimate sulfur content in a given sulfate solution of sodium sulphate gravimetrically.
4. To determine the rate constant and order of the reaction of the hydrolysis of an ester (ethyl acetate) at 25^0 C in the presence of 0.5 N hydrochloric acid.
5. To determine the strength of given solution conductometrically.
6. To determine the strength of the given solution pH-metrically
7. To determine the total hardness of the given hard water sample by EDTA method.
8. To determine the alkalinity of a given water sample.
9. To prepare Urea-Formaldehyde (UF) resin.
10. To determine the strength of given solution of NaOH by titrating it against standard oxalic acid solution using phenolphthalein using virtual lab.
    Link : http://vlab.amrita.edu/?sub=2&brch=193&sim=352&cnt=4

Text Books:

1. Practicals in Physical Chemistry: A Modern Approach by Sindhu, P.S., Publisher: Delhi Macmillan India,

ISBN: 1403929165
2. Theory and Practicals of Engineering Chemistry by Chawla, Shashi, Publisher: New Delhi Dhanpat Rai & Co., ISBM: 9788177000405, 8177000403
3. Practical Physical Chemistry by B. Viswanathan, Publisher: Viva Books, ISBML 9788130920696

CO/PO Mapping for the course:

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	-	-	-	-	1	-	-	-	2	-	-	-	-	-
CO2	-	-	-	-	1	1	-	3	2	-	-	-	-	-
CO3	-	-	-	-	1	1	-	3	2	-	-	-	-	-
Avg	-	-	-	-	1	1	-	3	2	-	-	-	-	-

SEMESTER III

CHCE 2025	Material and Energy Balance Computations	L	T	P	C
		3	0	0	3
Pre-requisites/Exposure	Mathematics I and II				
Co-requisites	Process Chemistry				

Course Objectives:

1. To introduce students to system of units and conversion of stream variables from one-unit system to another.
2. To understand and analyse the process by identifying systems and apply the degree of freedom analysis.
3. To perform the steady state material balances on the subsets of the process or the entire process in order to estimate the flow rate and compositions without reactions and with reactions.
4. To enable students to understand basic concepts of energy balance for different processes.

Course Outcomes:

CO1. Understanding the concept of physical quantities, unit conversion, stoichiometry, vapor/liquid equilibria, crystallization and humidification.
CO2. Solving the material and energy balance problem of chemical engineering process
CO3. Analyse the material and energy balance with recycle, bypass and purge
CO4. Evaluate the material and energy balance of multiple units

Course Descriptions:

Chemical Process industries are concerned with the conversion of raw materials into useful products. This conversion takes place through chemical conversions and physical operations. The significance of Chemical Process Calculations and applications is well known in the different fields of Engineering and Technology. The understanding of material and energy with or without chemical reaction is very vital for process design. The equipment design for the process starts only after the completion of the material and energy balance calculation of the process. The feasibility of the process can be understood by the calculations. In this course, more emphasis is given on the units and conversion, basic concept of calculations, behavior of gases, humidity and saturation, material balance with or without chemical reactions, recycle streams, purge, bypass, and energy balances. The objective of this course is to equip the students to perform analysis of processes through process calculations and develop in them problem-solving skills.

Course Curriculum:

Unit 1: Introductory concepts of units, physical quantities in chemical engineering, dimensionless groups, "basis" of calculations — 7 Hours

Unit 2: Material Balance: Introduction, solving material balance problems without chemical reaction; With chemical reaction, Concept of stoichiometry and mole balances, examples, including combustion; Material Balances with recycle, bypass and purge; Calculations using Spreadsheets/MS Excel — 12 Hours

Unit 3: Gases, Vapors and Liquids: Vapor pressure, Cox chart, Duhring's plot — 7Hours

Unit 4: Energy balance: open and closed system, heat capacity, calculation of enthalpy changes; Energy balances with chemical reaction: Heat of reaction, Heat of combustion; Calculations using Spreadsheets/MS Excel — 12Hours

Unit 5: Crystallization, Dissolution; Humidity and Saturation, humid heat, humid volume, dew point, humidity chart and its use — 7 Hours

Text Books:

1. Himmelblau, David M. (2003) Basic Principles and Calculations in Chemical Engineering, Prentice-Hall of India Pvt. Ltd., New Delhi. ISBN: 8120311450.
2. Hougen, O.A., Watson, K. M. (2004) Chemical Process Principles, CBS Publishers & Distributors Pvt. Ltd., New Delhi. ISBN: 8123909539.

Reference Books:

1. Bhatt, B. I. and Vohra, S. M. (2004) Stochiometry, Tata McGraw-Hill publishing Company Ltd., New Delhi. ISBN:0070494940.
2. Narayanan, K. V., Kutty, B. Lakshmi (2006) Stochiometry and Process Calculations Prentice Hall of India Limited, New Delhi. ISBN: 9788120329928.
3. Gavhane, K. A. (2009) Introduction to Process Calculations, Nirali Prakashan, Pune. ISBN: 9788190631668.

CO/PO Mapping for the course:

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	-	-	-	-	-	-	-	-	-	-	-	3	-
CO2	-	-	2	-	-	-	-	-	-	-	-	-	-	-
CO3	-	2	-	-	-	-	-	-	-	-	-	-	-	-
CO4	-	2	-		-	-	-	-	-	-	-	-	-	-
Avg	3	2	2	-	3	-	-	-	-	-	-	-	3	3

CHCE 2003	Momentum Transfer	L	T	P	C
		3	1	0	4
Pre-requisites/Exposure	Mathematics I and II				
Co-requisites	Thermodynamics				

Course Objectives:

1. To introduce the fundamental aspects of the fluid flow behavior.
2. To present the basic principles and equations of fluid mechanics.
3. To give a general overview and relationship between momentum, heat and mass conservation equations.
4. Study analytical solutions to variety of simplified problems.
5. Determine performance characteristics of fluid machinery.

Course Outcomes:

CO1. Understanding the fluid properties and the basic concepts of fluid statics, kinematics and dynamics.
CO2. Applying the mass, momentum and energy balance equations in solving the fluid mechanics problem
CO3. Analyse the flow measuring and fluid transportation system based on fluid mechanics concept.
CO4 Evaluate the performance of flow transportation equipment.

Course Descriptions:

Momentum transfer is an exciting and fascinating subject with unlimited practical applications ranging from microscopic biological systems to automobiles, airplanes, and spacecraft propulsion. Momentum transfer has also historically been one of the most challenging subjects for undergraduate students because proper analysis of fluid mechanics problems requires not only knowledge of the concepts but also physical intuition and experience. The fluid-mechanical phenomenon is complex enough thus the level of mathematics will be kept minimum in this course and the major emphasis will be on understanding the basic concept. The aim during the discussion of this subject will be to make the students to be independent thinkers.

Course Curriculum:

Unit 1: Properties of Fluids - Density, Specific volume, Viscosity, Compressibility, Types of fluid, Power law; Types of fluid flow — 4+1 Hours

Unit 2: Fluid Statics and Kinematics - Pressure, Pascal Law applications, Hydrostatic Law, Hydraulic pressure, Manometers and hydrostatic pressure, Surface tension and capillary action; Flow description using Lagrangian and Eulerian approaches, Relationship between material and local derivatives of fluid properties. — 8+3 Hours

Unit 3: Fluid Dynamics - Conservation equation of mass, momentum and energy balances in both integral and differential forms, Specific cases of equation of continuity and motion and energy: Naiver Stokes Equation; Hagen Poiseuille Law; Engineering Bernoulli's Equation; Calculations and balances using spreadsheets/ MS Excel — 12+4 Hours

Unit 4: Engineering Application 1: Flow measuring Devices - Venturi meter, Orifice meter, Rotameter, Pitot tube, time of emptying tank, Weirs and Notches — 6+2 Hours

Unit 5: Engineering Application 2: Pipeline System - Major and Minor Losses; Energy requirement in pipeline systems; Introduction to pumps, blowers, fans, compressor; Pumps – Types of pumps, Pump priming and cavitation, Affinity laws for pumps, System and Pump Characteristics Curves, — 15+5 Hours

NPSH calculations; Calculations using spreadsheets/MS Excel; Use Pipesim software for designing of pipeline systems.

Text Books:

1. Santosh K. Gupta, Momentum Transfer Operations, Tata McGraw Hill, New Delhi, 1979 (out of print)
2. V. Gupta and S. K. Gupta, Fluid Mechanics and its Applications, 3rd Ed., New Age Intl Pub., New Delhi, 2016
3. W. L. McCabe, J. C. Smith and P. Harriot, Unit Operations of Chemical Engineering (Intl Edn.), 7th Edition, McGraw Hill, New York, 2004.

Reference Books:

1. R.W. Fox, P.J. Pritchard & A. T. McDonald, Fluid Mechanics. 2011, 8th Edition, John Wiley & Sons Inc.
2. W. L. McCabe, J. C. Smith and P. Harriot, Unit Operations of Chemical Engineering, 7th Edition, McGraw Hill, New York, 2004.
3. K. Kundu, Pijush, and Ira M. Cohen. Fluid Mechanics. 3rd ed. Burlington, 2004.
4. A. Fay, James Introduction to Fluid Mechanics. Cambridge, MA: MIT Press, 1994.
5. R. K. Rajput, Fluid Mechanics and Hydraulic Machines. 6th edition, ISBN-13: 978-9385401374, S Chand & Company, 2016.
6. R. K. Bansal A Textbook of Fluid Mechanics and Hydraulic Machines, 9th edition, ISBN-13: 978-8131808153, Laxmi Publications, 2017.

CO/PO Mapping for the course:

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	-	-	-	-	-	-	-	-	-	-	-	-
CO2	3	3	3	-	-	-	-	-	-	-	-	-	-	-
CO3	3	3	3	3	3	-	-	-	-	-	-	-	3	3
CO4	3	3	-	-	-	-	-	-	-	-	-	-	3	3
Avg	3	3	3	3	3	-	-	-	-	-	-	-	3	3

CHCE 2002	Chemical Engineering Thermodynamics I	L	T	P	C
		3	1	0	4
Pre-requisites/Exposure	Mathematics I and II				
Co-requisites					

Course Objectives:

1. To understand the laws of thermodynamics and its applicability
2. To understand the concept of enthalpy, internal energy, entropy and Gibbs energy
3. To understand and apply equation of states
4. To be able to solve complex chemical problems using the thermodynamic principles

Course Outcomes:

CO1. Understand the basics of thermodynamics, mass and energy conservation principle.
CO2. Compute the thermodynamic properties of fluids, work, and heat for closed and open system.
CO3 Examine the feasibility of process based upon thermodynamic laws.
CO4 Evaluate the performance of different thermodynamic cycles.

Course Descriptions:

Thermodynamics relates work, heat, temperature, and states of matter to each other. From a surprisingly small set of empirically based laws, an enormous amount of information about the relationships among equilibrium parameters for a system can be deduced. This information can then be applied to physical, chemical, and biological systems including chemical process design, materials processing, and cellular processes.

Course Curriculum:

Unit 1: Introduction- Terminology, scope of thermodynamics, Thermodynamic systems; Basic concepts on Temperature, Pressure, Work, Energy, Heat	6 Hours
Unit 2: Energy conservation & first law of thermodynamics; State functions; Equilibrium; Phase Rule; Reversible process; Constant P, V, T processes; Mass and energy balances for open systems.	12+5 Hours
Unit 3: Phases, phase transitions, PVT behavior; description of materials – Ideal gas law, virial and cubic equations of state; Reduced conditions and corresponding states theories; correlations in description of material properties and behavior; Calculations done using tools like spreadsheets/MS Excel; Defining Thermodynamic packages in simulators (ASPEN/DWSim)	10+5 Hours
Unit 4: Statements of the second law; Heat engines, Carnot's theorem; Thermodynamic Temperature Scales; Entropy; Entropy changes of an ideal gas; Mathematical statement of the second law; Entropy balance for open systems; Calculation of ideal work, Lost work.	10+5 Hours
Unit 5: Application of thermodynamics to flow processes-pumps, compressors and turbines; The Carnot refrigerator; Vapor-compression cycle; Absorption refrigeration; Heat pump, Liquefaction processes	7 Hours

Text Books:

1. Engineering Thermodynamics by Prof. P.K. Nag, TMH, , 3rd Ed.
2. Introduction to Chemical Engineering Thermodynamics by H.C. Van Ness, Micheal. M. Abott, J.M, Smith., McGraw – Hill, 6th edition

Reference Books:

1. Çengel, Yunus A. Thermodynamics : an Engineering Approach. Boston: McGraw-Hill Higher Education, 2008.
2. A text book of Chemical Engineering Thermodynamics by K. V. Narayanan, PHI, 2nd Ed.
3. Chemical Engineering Thermodynamics, Y. V. C. Rao, University Press

CO/PO Mapping for the course:

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	-	-	-	-	-	-	-	-	-	-	-	3
CO2	3	3	3	-	3	-	-	-	-	-	-	-	-	3
CO3	3	3	-	-	-	-	-	-	-	-	-	-	3	3
CO4	3	3	3	3	-	-	-	-	-	-	-	-	3	3
Avg	3	3	3	3	3	-	-	-	-	-	-	-	3	3

CHCE 2021	**Process Heat Transfer**	**L**	**T**	**P**	**C**
		3	**1**	**0**	**4**
Pre-requisites/Exposure	Basics of Physics; Material and Energy Balance computations, Thermodynamics-1				
Co-requisites					

Course Objectives:

1. Understand the concept and importance of heat transfer in chemical engineering process
2. Understand the different modes of heat transfer and their applications
3. Design simple Heat exchangers using tools like MS Excel/Process simulators

Course Outcomes:

CO1 Understanding the basic concept of heat transfer principles and heat transfer equipment
CO2 Applying the heat transfer principles to estimate the heat transfer rate
CO3 Analyze the effect of variables on the heat transfer operation
CO4 Evaluate the performance and operation of heat transfer equipment

Course Descriptions:

Heat transfer is a science that deals with the rate of transfer of thermal energy. In this course, three modes of heat transfer-conduction, convection and radiation- are studied in detail. With the knowledge of mechanism of heat transfer, heat exchangers are designed. Heat exchangers are widely used in many processes industries.

Course Curriculum:

Unit 1: Fundamentals of Heat Transfer – Introduction to Heat transfer; Analogies between transport processes; Modes of Heat Transfer; Fourier's Law; Newton Law of cooling; Stefan Boltzmann Law;	3 Hours
Unit 2: Heat Transfer by Conduction – Concept of heat conduction; Thermal conductivity; Thermal diffusivity; Linear one-dimensional heat conduction (rectangular and radial coordinates); Composite structures; Critical Insulation thickness for pipes; Extended surfaces (fins); Efficiency and effectiveness of fins;	12+5 Hours
Unit 3: Heat Transfer by Convection – Concept of convection; Nusselt's Number; Determination of Nusselt's number; Forced Convection; Heat transfer in laminar system; Thermal boundary layer; Reynold's Analogy; Free convection	7+2 Hours
Unit 4: Heat transfer with change of phase – Phenomena of boiling; Regimes of pool boiling; Nucleate boiling; Condensation; film condensation on a vertical surface and tubes	5 +2Hours
Unit 5: Thermal Radiation – Absorption; Transmission; Reflection and Emission; Black body concept; Emissivity; Kirchhoff's Law; Wien's Displacement Law; Lambert's Cosine Law; Radiation characteristics for real and black body; Radiation Shield	5+1 Hours
Unit 6: Heat Exchangers – Heat Exchanger types; Fouling factor; Over all heat transfer coefficient; LMTD; LMTD correction factors; Kern's method, Number of transfer units; Heat exchanger effectiveness; Introduction to double pipe and shell and tube heat exchanger design using MS Excel/Process simulators	13+5 Hours

Text Books:

1. Heat and Mass Transfer, by J.P. Holman, Tata McGraw Hill, New Delhi, 2000.
2. Heat and Mass Transfer, by P.K. Nag, Tata McGraw Hill New Delhi, 2002.

Reference Books:

1. Heat Transfer, A Practical Approach, by Y. A. Cengel, Tata McGraw Hill, New Delhi, 2003.
2. Heat Transfer Principles and Applications, by B. K. Dutta, Prentice Hall of India, 2004.

CO/PO Mapping for the course:

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	-	-	-	-	-	-	-	-	-	-	-	3
CO2	3	3	-	-	-	-	-	-	-	-	-	-	-	3
CO3	3	3	3	3	-	-	-	-	-	-	-	-	3	3
CO4	3	3	3	3		-	-	-	-	-	-	-	3	3
Avg	3	3	3	3		-	-	-	-	-	-	-	3	3

SEMESTER IV

CHCE 2020	Mass Transfer I	L	T	P	C
		3	1	0	4
Pre-requisites/Exposure	Basics of Physics; Material and Energy Balance computations				
Co-requisites	Thermodynamics				

Course Objectives:

1. To enhance the student's understanding in the field of Mass Transfer-I.
2. To increase the student's concepts in the field of Mass Transfer-I.
3. To enable students', acquire knowledge in the field of separation processes including, distillation.

Course Outcomes:

CO 1 Understanding the mass transfer principles and vapour/liquid equilibria and gas/liquid contacting equipment.

CO 2 Applying mass transfer theories to compute mass transfer coefficient and vapour/liquid equilibria.

CO 3 Analyse the gas/liquid contact strategy of mass transfer equipment.

CO 4 Evaluate the performance of distillation column.

Course Descriptions:

Introduction to principles and applications of mass transfer, with focus on the design of equilibrium stage and continuous contacting separation processes. The aim of this module is to deepen the students' knowledge of the unit operations with a focus on distillation, absorption, adsorption and drying processes. This provides a foundation for the Chemical Engineering in Practice.

Course Curriculum:

Unit 1: Introduction to mass transfer; Diffusion; Constitutive laws of diffusion; Fick's Law; Mass transfer fluxes; Diffusion in Gases; Diffusion in liquids, Equimolar diffusion, Diffusion through stagnant medium, Knudsen diffusion, Eddy diffusion — 10+3 Hours

Unit 2: Convective mass transfer Convective mass transfer and mass transfer coefficient: The mass transfer coefficient, types of mass transfer coefficients, dimensionless groups in mass transfer, correlations for the convective mass transfer coefficients, eddy diffusion, the wetted wall column, theories of mass transfer, momentum, heat and mass transfer analogies. — 9+3 Hours

Unit 3: Interphase mass transfer: Equilibrium between phases, The Raoult's law and Henry's law, mass transfer between two phases, the overall mass transfer coefficient, material balance in a contacting equipment-the operating line, mass transfer in stage-wise contact of two phases — 5+2 Hours

Unit 4: Vapor-Liquid Equilibria; Relative volatility; Single Staged Distillation process (Flash); Differential Distillation; Continuous Distillation process (Mc-Cabe Thiele Method); Use of Chemical Process Simulators (ASPEN plus/DWSim) for designing; — 14+5 Hours

Unit 5: Gas Liquid contacting equipment; Basic design of tray columns; Tray column behavior (flooding; entrainment; weeping; coning etc.); Use of Chemical Process Simulators for designing. — 7+2 Hours

Text Books:

1. R. E. Treybal, Mass Transfer Operations, 3rd Ed., McGraw Hill, New York, 1980.
2. J. D. Seader and E. J. Henley, Separation Process Principles, 2nd Ed., Wiley, New York, 2006

Reference Books:

1. Christie John Geankoplis: "Transport Processes and Unit Operations", 4th Edition, Prentice Hall, 2003.
2. Binay K. Dutta, Principles of Mass Transfer and separation processes, PHI Learning Pvt. Ltd, 2007.

CO/PO Mapping for the course:

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	-	-	-	-	-	-	-	-	-	-	-	-
CO2	3	3	3	-	-	-	-	-	-	-	-	-	-	-
CO3	3	3	3	3	3	-	-	-	-	-	-	-	3	3
CO4	3	3	-	-	-	-	-	-	-	-	-	-	3	3
Avg	3	3	3	3	3	-	-	-	-	-	-	-	3	3

CHCE 2008	Chemical Engineering Thermodynamics II	L	T	P	C
		3	1	0	4
Pre-requisites/Exposure	Basic Knowledge of differential calculus; Basic Knowledge of thermodynamics-1				
Co-requisites					

Course Objectives:

1. Apply basic chemistry and engineering concepts to thermodynamic systems.
2. Use the laws of classical thermodynamics for engineering problems
3. Apply concepts of thermodynamic to solutions and vapour liquid equilibria

Course Outcomes:

CO 1 Understanding the concept of phase and reaction equilibrium.
CO 2 Solve the simple phase/reaction equilibrium problems using thermodynamic principles
CO 3 Analyze the effect of thermodynamic model to describe the phase equilibria
CO 4 Evaluate the equilibrium conversion of single and multiple reactions

Course Descriptions:

Thermodynamics relates work, heat, temperature, and states of matter to each other. From a surprisingly small set of empirically based laws, an enormous amount of information about the relationships among equilibrium parameters for a system can be deduced. This information can then be applied to physical, chemical, and biological systems including chemical process design, materials processing.

Course Curriculum:

Unit 1: Review of first and second law of thermodynamics; Thermodynamic property of fluids, Potential Functions, Maxwell relations, 2-phase systems; Clausious-Claypeyron Equation	8+3 Hours
Unit 2: Vapor-liquid equilibrium: phase rule; simple models for VLE; VLE by Raoult's law and modified Raoult's law; VLE from K-value correlations; Flash calculations.	8+4 Hours
Unit 3: Solution Thermodynamics: fundamental property relationships, free energy and chemical potential, partial properties, definition of fugacity and fugacity coefficient of pure species and species in solution, the ideal solution and excess properties; Calculations using tools like MS Excel/Spreadsheets	12+4 Hours
Unit 4: Liquid phase properties from VLE, Models for excess Gibbs energy, heat effects and property change on mixing; Calculations using tools like MS Excel/Spreadsheets	5+1 Hours
Unit 5: Liquid-Liquid Equilibria; Vapor-Liquid-Liquid Equilibria; Solid-Liquid Equilibria; Solid-Gas Equilibria	4 Hours
Unit 6: Chemical reaction equilibria: equilibrium criterion, equilibrium constant, evaluation of equilibrium constant at different temperatures, equilibrium conversion of single reactions, multi-reaction equilibria.	8+3 Hours

Text Books:

1. Introduction to Chemical Engineering Thermodynamics by H.C. Van Ness, Micheal. M. Abott, J.M, Smith., McGraw – Hill, 6th edition
2. A text book of Chemical Engineering Thermodynamics by K. V. Narayanan, PHI, 2nd Ed.
3. Chemical Engineering Thermodynamics, Y. V. C. Rao, University Press

Reference Books:

4. Poling, Bruce E., John M. Prausnitz, and John P. O'connell. Properties of gases and liquids. McGraw-Hill Education, 2001.
5. Koretsky, Milo D. Engineering and chemical thermodynamics. John Wiley & Sons, 2012.

CO/PO Mapping for the course:

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	3	2	-	-	-	-	-	-	-	-	2	3
CO2	3	2	3	2	3	-	-	-	-	-	-	-	2	3
CO3	3	1	-	-	-	-	-	-	-	-	-	-	1	3
CO4	3	3	3	2	-	-	-	-	-	-	-	-	3	3
Avg	3	2	3	2	3	-	-	-	-	-	-	-	2	3

CHCE 2019	Numerical Methods in Chemical Engineering	L	T	P	C
		3	1	0	4
Pre-requisites/Exposure	Mathematics I and II				
Co-requisites					

Course Objectives:

1. To help students develop skills in computational techniques used in Chemical Engineering.
2. To help them understand the use of various numerical techniques to solve Chemical Engineering problems
3. To enable students, make simple computer programs in MS EXCEL/MATLAB using some of these techniques.

Course Outcomes:

CO1. Understanding the basic concept of linear/nonlinear equation and ordinary and partial differential equation.
CO2. Solve the system of linear (SLEs) and nonlinear algebraic equations (SNLEs)
CO3. Analyze the numerical algorithm for SLEs and SNLEs, curve fitting, differentiation and integration
CO4. Evaluate an efficient numerical approach to solve ordinary/partial differential equation.

Course Descriptions:

Understanding the techniques of formulating and solving several common sets of equations arising in Chemical Engineering and making computer programs to obtain numerical answers is an extremely important part of Chemical Engineering. Lectures will elaborate the techniques, while the Tutorials will help students make computer programs to get a hands-on experience in obtaining solutions. In the later part of the semester, students will be encouraged to interact and obtain numerical solutions to more difficult problems.

Course Curriculum:

Unit 1: Introduction, Approximation and Concept of Error & Error Analysis	3 Hours
Unit 2: Linear Algebraic Equations: Methods like Gauss elimination, LU decomposition and matrix inversion, Gauss-Siedel method, Chemical engineering problems involving solution of linear algebraic equations; Problem solving using MS Excel/MATLAB/Scilab	8 Hours
Unit 3: Root finding methods for solution on non-linear algebraic equations: Bisection, Fixed point iteration method, Newton- Raphson method, Chemical engineering problems involving solution of non-linear equations; Problem solving using MS Excel/MATLAB/Scilab	8 Hours
Unit 4: Interpolation and Approximation, Newton's polynomials and Lagrange polynomials, spline interpolation, linear regression, polynomial regression, least square regression	6 Hours
Unit 5: Numerical integration: Trapezoidal rule, Simpson's rule, Chemical engineering problems involving numerical differentiation and integration; Problem solving using MS Excel/MATLAB/Scilab	8 Hours
Unit 6: Ordinary Differential Equations: Euler method, Runge-Kutta method, Adaptive Runge-Kutta method, Initial and boundary value problems, Chemical engineering problems involving single, and a system of ODEs; Problem solving using MS Excel/MATLAB/Scilab	12 Hours
Unit 7: Introduction to Partial Differential Equations: Characterization of PDEs, Laplace equation, Heat conduction/diffusion equations, explicit, implicit, Crank-Nicholson method.	3 Hours

Text Books:

1. Gupta, Santosh K.; Numerical Methods for Engineers, New Age Intl. Publishers, New Delhi, 3rd (Indian) Ed., 2015; 3rd (NAS, *UK*) Ed., 2014.
2. Davis, M. E.; Numerical Methods and Modelling for ChE, Wiley, New York, 1984 (short, yet good presentation), re-published by Dover Publications, 2013

Reference Books:

1. Chapra, S. C. and Canale, R.; Numerical Methods for Engineers, 7th Ed., 2016 (softcover Indian edition), McGraw Hill, India (a best-seller)
2. Srivastava, R. and Guha, S.: Numerical Methods for Engineering and Science, 2010 (softcover edition), Oxford University Press India (written for an undergraduate course at IIT Kanpur)
3. Carnahan, B.; Luther, H. A. and Wilkes, J. O.; Applied Numerical Methods, Wiley, New York, 1969 (a bit outdated now – yet a classic when it first came out)
4. Rudra Pratap, Getting Started with MATLAB: A Quick Introduction for Scientists and Engineers, 7th Edition, Oxford University Press

CO/PO Mapping for the course:

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	-	-	2	-	-	-	-	-	-	-	-	-
CO2	3	3	3	-	2	-	-	-	-	-	-	-	-	3
CO3	3	3	3	3	2	-	-	-	-	-	-	-	-	3
CO4	3	3	3	3	2	-	-	-	-	-	-	-	-	3
Avg	3	3	3	3	2	-	-	-	-	-	-	-	-	3

SLLS 0202	Data Analytics & Machine Learning	L	T	P	C
		3	0	0	3
Pre-requisites/Exposure	Basic Knowledge of computer				
Co-requisites					

Course Objectives:

This course will enable the students:

1. To introduce the concepts of data modelling techniques using Machine Learning for Data
2. Learn about state-of-the-art Machine Learning techniques
3. Apply them in real life problems.

Course Outcomes:

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

CO1 Learn the probability and statistics

CO2 Summarize various regression models

CO3 Articulate data analytics using programming languages.

Course Description:

Data Analytics & Machine learning is an emerging field of information technology. Recently a big corporate house enquired at the time of campus interview whether the course on Data Analytics & Machine learning is offered here. Machine learning part of this course is needed for data modelling, that is for preparing data for data analysis, and Statistical methods are applied on data for Data Analysis and Data Mining.

Course Curriculum:

Unit 1: Review of Statistical methods

Descriptive Statistics: Probability Distributions (Binomial, Poisson, Normal), Sampling Distributions (Chi-squared, t, F), Inferential Statistics like Test of Hypothesis, Estimation. Regression &Analysis of Variance (ANOVA)

Unit II: Introduction to Machine Learning

Introduction and Concepts, differentiating algorithmic and model based frameworks, Regression: Ordinary Least Squares, Ridge Regression, Lasso Regression, K Nearest Neighbours Regression & Classification.

Unit III: Supervised Learning with Regression and Classification techniques.

Bias-Variance Dichotomy Model Validation Approaches, Logistic Regression, Linear Discriminant Analysis Quadratic Discriminant Analysis, Regression and Classification Trees, Support Vector Machine (SVM).

Unit IV: Learning, Regression and Classification techniques

Supervised and Unsupervised Learning concepts, Regression and Classification techniques, Neural Networks, Clustering, Association Rule Mining, Deep learning Concepts, Challenges for Big data Analytics.

Unit V: Prescriptive analytics

Creating data for analytics through Active learning, Creating data for analytics through Reinforcement learning, Python Machine Learning & Data Analysis Tutorial/Lab.

TEXT BOOK:

1. Montgomery, Douglas C., and George C. Runger. Applied Statistics and Probability for Engineers. John Wiley & Sons, 2010
2. Artificial Intelligence: A Modern Approach, Stuart Russel & Peter Norvig, Pearson, 2009
3. Machine Learning: A probabilistic perspective ,kevin P. Murphy
4. Pattern Recognition and Machine Learning, Chris Bishop
5. The Elements of Statistical Learning: Data Mining, Inference, and Prediction, Trevor Hastie, Robert Tibshirani, Jerome Friedman

REFERENCE:

1. Business Intelligence: A Managerial Perspective on Analytics, Ramesh Sharda, Dursun Delon, Efraim Turbal, David King, Prentice Hall
2. Modellind Techniuqes in Predictive Analytics, Thomas W Miller, Pearson
3. Introduction to Machine Learning with Python, A. C. Muller & S. Guido, O'Reilly.

CO/PO Mapping for the course:

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	-	-	2	-	-	-	-	-	-	-	-	-
CO2	3	3	3	-	2	-	-	-	-	-	-	-	-	3
CO3	3	3	3	3	2	-	-	-	-	-	-	-	-	3
CO4	3	3	3	3	2	-	-	-	-	-	-	-	-	3
Avg	3	3	3	3	2	-	-	-	-	-	-	-	-	3

CHCE 2103	Momentum Transfer Lab	L	T	P	C
		0	0	1	1
Pre-requisites/Exposure	Momentum Transfer course				
Co-requisites					

Course Outcomes:

CO1. Illustrate fundamental knowledge in understanding the practical problem and finding the engineering solution.
CO2. Interpret the data obtained from the experiments and operate the equipment.
CO3. Solve the given problem using the correct chemical engineering principles and reporting with proper documentation.
CO4. Use teamwork and ethical principles in solving engineering problem with a measure to o overcome obsolescence.

Experiments List:

Experiment No: 01 BERNOULLI'S THEOREM APPARATUS - To verify the Bernoulli's equation using the Venturi meter
Experiment No: 02 APPARATUS FOR CONDUCTING ORIFICE EXPERIMENTS - To determine the Coefficient of discharge Cd, Velocity Cv and Contraction Cc of various types of Orifices and Mouthpieces.
Experiment No: 03 REYNOLD'S APPARATUS - To study different flow conditions. To study the Reynolds number in different flow conditions
Experiment No: 04 NOTCH APPARATUS TO CALIBRATE RECTANGULAR AND V- NOTCH -Determination of discharge coefficients of: a) V- Notch (V) b) Rectangular notch (U)
Experiment No: 05 DARCY'S LAW APPARATUS - To verify Darcy's law and to find out the coefficient of permeability of the given medium.
Experiment No: 06 IMPACT OF JET APPARATUS - To verify the momentum equation experimentally.
Comparison of change in force exerted due to shape of the vane for different targets.
Experiment No: 07 PIPE FRICTION APPARATUS - To study the variation of friction factor, 'f' for turbulent flow in rough and smooth commercial pipes.
Experiment No: 08 APPARATUS FOR DETERMINATION OF LOSSES IN PIPE FITTINGS
To determine the minor head loss coefficient for different pipe fittings.
Experiment No: 09 FLOW MEASUREMENT APPARATUS - To calibrate a Venturi meter and to study the variation of coefficient of discharge with the Reynolds number; To calibrate an Orifice meter and study the variation of coefficient of discharge with Reynolds number
Experiment No: 10 COMPUTERISED RECIPROCATING PUMP TEST RIG
Experiment No: 11 GEAR AND VANE PUMP TEST RIG
Experiment No: 12 COMPUTERISED CENTRIFUGAL PUMP TEST RIG

Reference Books:

1. Laboratory Manuals
2. Santosh K. Gupta, Momentum Transfer Operations, Tata McGraw Hill, New Delhi, 1979 (out of print)
3. V. Gupta and S. K. Gupta, Fluid Mechanics and its Applications, 3rd Ed., New Age Intl Pub., New Delhi, 2016
4. W. L. McCabe, J. C. Smith and P. Harriot, Unit Operations of Chemical Engineering (Intl Edn.), 7th Edition, McGraw Hill, New York, 2004.

CO/PO Mapping for the course:

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	-	-	-	-	-	-	-	-	-	-	-	-	-
CO2	-	-	-	3	-	-	-	-	-	-	-	-	2	-
CO3	-	-	-	-	-	-	-	-	-	2	-	-	-	3
CO4	-	-	-	-	-	-	-	3	3	-	-	3	-	-
Avg	3	-	-	3	-	-	-	3	3	2	-	3	2	3

	Heat Transfer Lab	L	T	P	C
		0	0	1	1
Pre-requisites/Exposure	Heat transfer course				
Co-requisites					

Course Outcomes:

CO1. Illustrate fundamental knowledge in understanding the practical problem and finding the engineering solution.
CO2. Interpret the data obtained from the experiments and operate the equipment.
CO3. Solve the given problem using the correct chemical engineering principles and reporting with proper documentation.
CO4. Use teamwork and ethical principles in solving engineering problem with a measure to o overcome obsolescence.

Experiments List:

1. Conduction through composite wall - To study the heat transfer through conduction in composite wall and to calculate thermal resistance and thermal conductivity of composite wall.
2. Thermal Conductivity of Metal Rod - To determine the thermal conductivity of a metal rod using one-dimensional heat conduction equation.
3. Pin fin in Natural & Forced Convection - To measure temperature profiles of a pin fin heated at its bottom at natural and forced convection and estimation of temperature profiles and to compare it with experimentally observed values.
4. Free/Natural Convection - This experiment determines the heat transfer coefficient from the outer side of a vertical electrically heated tube in air during natural convection and to determine the heat transfer coefficient from the given empirical equation and compare it with the experimental value obtained.
5. Forced Convection - To determine the convective heat transfer coefficient for forced convection due to flow of air across the heated tube.
6. Stefan Boltzmann's Law - To study the radiation heat transfer by black body and to study the effect of hemisphere temperature on it and to calculate the Stefan Boltzmann constant.
7. Dropwise and film wise condensation - To study the rate of condensation and heat transfer coefficient.

Reference Books:

1. Laboratory Manuals
2. Heat and Mass Transfer, by J.P. Holman, Tata McGraw Hill, New Delhi, 2000.
3. Heat and Mass Transfer, by P.K. Nag, Tata McGraw Hill New Delhi, 2002.

CO/PO Mapping for the course:

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	-	-	-	-	-	-	-	-	-	-	-	-	-
CO2	-	-	-	3	-	-	-	-	-	-	-	-	2	-
CO3	-	-	-	-	-	-	-	-	-	2	-	-	-	3
CO4	-	-	-	-	-	-	-	3	3	-	-	3	-	-
Avg	3	-	-	3	-	-	-	3	3	2	-	3	2	3

SEMESTER V

CHCE 3004	Chemical Reaction Engineering I	L	T	P	C
		3	1	0	4
Pre-requisites/Exposure	Basic knowledge of chemical engineering; Basic knowledge of chemistry				
Co-requisites					

Course Objectives:

1. Apply the fundamental principles of chemical reaction kinetics and thermodynamics to problems involving mass and energy balances with reaction.
2. Design different types of chemical reactors (Batch, Tubular, and CSTR).
3. Assess the advantages and disadvantages of each reactor type.
4. Analyze experimental kinetic data to determine reaction mechanisms.

Course Outcomes:

CO1. Understanding the fundamentals of reaction, kinetics and reactor.
CO2. Solve the rate equations by using reactor data and use modern tool for calculations
CO3. Analyse the batch and continuous reactors with single reactions
CO4. Evaluate the ideal reactors for multiple reactions

Course Descriptions:

Chemical Reaction Engineering - I is the main course covering the engineering science of chemical kinetics, reactor analysis, as well as reactor design. It is the engineering activity concerned with the exploitation of chemical reactions on a commercial scale. Its goal is the successful design and operation of chemical reactors, and probably more than any other activity it sets chemical engineering apart as a distinct branch of the engineering profession. The engineering science and reactor design skills taught in this course are considered essential for any practicing chemical engineer.

Course Curriculum:

Unit 1: Reactions and reaction rates - stoichiometry, extent of reactions, conversion, Selectivity Reaction rate fundamentals - elementary reaction sequences, steady state approximation and rate limiting step theory; Order of reaction	6+2 Hours
Unit 2: Analysis and correlation of experimental kinetic data - data collection & plotting, linearization of rate equations, differential and integral method of analysis; Calculation using tools like MS Excel/Spreadsheets	12+4 Hours
Unit 3: Ideal reactors - generalized material balance, design equations, graphical – interpretation; Calculation using tools like MS Excel/Spreadsheets	9+3 Hours
Unit 4: Sizing and analysis of ideal batch, mixed (CSTR), plug flow and recycle reactors - solving design equations for constant and variable density systems, reactors in series and parallel; Calculation using tools like MS Excel/Spreadsheets	12+4 Hours
Unit 5: Multiple reactions - conversion, selectivity, yield, series, parallel, independent and mixed series-parallel reactions; Calculation using tools like MS Excel/Spreadsheets	6+2 Hours

Text Books:

1. Octave Levenspiel, "Chemical Reaction Engineering", 3rd edition, John Wiley & Sons India edition, 2011
2. Scott Fogler. H., "Elements of Chemical Reaction Engineering", 3rd edition, Prentice Hall of India, New Delhi, 2006.

Reference Books:

1. Smith. J.M., "Chemical Engineering Kinetics", 3rd edition, McGraw Hill International Editions, New Delhi, 1981.

2. Ronald. W.Missen, Charles.A.Mions, Bradley.A.Saville, "Introduction to Chemical Reaction Operation and Kinetics", John Wiley and Sons, Singapore, 1999.

CO/PO Mapping for the course:

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	3	1	-	-	-	-	-	-	-	-	3	3
CO2	3	2	3	3	3	-	-	-	-	-	-	-	3	3
CO3	3	2	3	2	-	-	-	-	-	-	-	-	3	3
CO4	3	3	3	3	3	-	-	-	-	-	-	-	3	3
Avg	3	2.3	3	2.3	3	-	-	-	-	-	-	-	3	3

CHCE 3029	**Mass Transfer II**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**
Pre-requisites/Exposure	Mass Transfer I; Thermodynamics				
Co-requisites					

Course Objectives:

1. To help the students of Chemical Engineering understand the basic principles of mass transfer.
2. To enable students to model and design staged and continuous columns involving mass transfer.
3. To enable students to model and design units involving absorption, liquid-liquid extraction, leaching, adsorption, humidification and drying.

Course Outcomes:

CO 1 Understanding the concept of different mass transfer operation

CO 2 Applying the material and energy balance in absorption, liquid-liquid extraction, leaching, adsorption, and cooling tower

CO 3 Analyze the single and multi-stage mass transfer operation

CO 4 Evaluate the performance of mass transfer equipment

Course Descriptions:

Mass transfer operations form an important part of a Chemical Engineer's repertoire. In this course, the principles of mass transfer are reviewed, and then *continuous* mass transfer operations/units are discussed.

Course Curriculum:

Unit 1: Absorption - Overview of Mass Transfer basics and principles; Introduction to Gas Absorption; Equilibrium solubility of gases in liquid; Counter-current multistage absorption process; Continuous- Contact Equipment; Calculations using process simulator software	12 Hours
Unit 2: Liquid-Liquid Extraction - Introduction to Liquid-Liquid Extraction; Ternary diagram; Single staged extraction process; multi-staged extraction process; liquid-liquid extraction equipment	9 Hours
Unit 3: Leaching – Introduction to Solid Liquid extractions; Single staged extraction process; multi-staged extraction process;	4 Hours
Unit 4: Adsorption - Introduction to Adsorption process; commercial adsorbents and their applications, characteristics and properties of adsorbents, selection of adsorbents, Adsorption isotherms; Counter-current multistage adsorption process; Continuous- Contact Equipment;	7 Hours
Unit 5: Simultaneous Heat and Mass Transfer Process – Introduction to Humidification; Gas-Liquid Contact operations; Adiabatic operations; Cooling tower; Introduction to Drying; Rate of Drying curve; Mechanism of Batch and continuous Drying; Calculations of drying time using MS Excel	13 Hours

Text Books:

1. R. E. Treybal, Mass Transfer Operations, 3rd Ed., McGraw Hill, New York, 1980.
2. J. D. Seader and E. J. Henley, Separation Process Principles, 2nd Ed., Wiley, New York, 2006

Reference Books:

1. Christie John Geankoplis: "Transport Processes and Unit Operations", 4th Edition, Prentice Hall, 2003.
2. Binay K. Dutta, Principles of Mass Transfer and separation processes, PHI Learning Pvt. Ltd, 2007.

CO/PO Mapping for the course:

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	-	-	-	-	-	-	-	-	-	-	-	-	3
CO2	3	3	3	3	3	-	-	-	-	-	-	-	3	3
CO3	3	3	3	3	-	-	-	-	-	-	-	-	3	3
CO4	3	3	3	3	3	-	-	-	-	-	-	-	3	3
CO4	3	3	3	3	3	-	-	-	-	-	-	-	3	3
Avg	3	3	3	3	3	-	-	-	-	-	-	-	3	3

CHCE 2026	**Particulate Technology**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**
Pre-requisites/Exposure	Mathematics, Chemistry, Physics				
Co-requisites					

Course Objectives:

1. To introduce students the important physical mechanisms occurring in processes involving particles.
2. To enable the students to be acquainted with the different laws for mechanical operations.
3. To understand and analyze the characteristics of particulate solids, principles of size reduction, particle dynamics and conveying of particulate solids.
4. To develop and solve mathematical descriptions of mechanical processes involving solids in chemical industries.

Course Outcomes:

CO1. Understanding the basic concepts of mechanical operations in chemical engineering, fluid and particle interaction, solid separation, and nanoparticles, size distribution of single particle and mixture of particles.
CO2. Apply the comminution laws and flow equations to solve the solid handling problems using modern engineering tools.
CO3. Analyse behaviour of solid/fluid flow dynamics, fluidization and solid separation
CO4. Evaluate the performance and efficiency of solid separation equipment.

Course Descriptions:

Particulate technology is the study related to the processing, handling, conversion and characterization of particulate matters (or materials), both wet or dry, with sizes ranging from few nanometers (~10-9 m) to centimeters (~10-2 m). In our daily life, we come across many materials or products, which are normally in the form of particulate matters and as chemical engineers, it is important to understand the processes involved during production of these products. Most of the Chemical manufacturing processes involve small solid particles. Proper design and handling of these fine particles is very important for the efficient operation. Many products such as catalyst, pharmaceuticals, fertilizers, cements are now manufactured in particulate forms. Mechanical operations find its applications in the areas of Materials science, Environmental, Biomedical, Pharmacy and medicine wherever solids are handled. The study of these operations is important since handling of solids is more difficult than handling liquids and gases. The course covers the properties and handling of particulate solids, size reduction, screening, filtration, sedimentation, fluidization processes.

Course Curriculum:

Unit 1: Introduction: Relevance of fluid and particle mechanics, and mechanical operations in chemical engineering processes; Solid particle characterization: particle size, shape and their distribution, relationship among shape factors and particle dimensions, specific surface area, measurement of surface area — 9 Hours

Unit 2: Size reduction, milling, laws of comminution, classification of particles; Size enlargement; nucleation and growth of particles; Transport of fluid-solid systems: pneumatic and hydraulic conveying; Calculations using engineering tools like MS Excel/Spreadsheet — 9 Hours

Unit 2: Flow around immersed bodies: concept of drag, boundary layer separation, skin and form drag, drag correlations; Packed beds: void fraction, superficial velocity, channeling, Ergun equation and its derivation, Carman- Kozeny equation, Darcy's law and permeability, Blaine's apparatus; — 6 Hours

Unit 3: Fluidization: Fluidized bed, minimum fluidization velocity, pressure drop, Geldart plot, etc. Types of fluidization: particulate fluidization, bubbling fluidization, classical models of fluidization, circulating fluidized beds, applications of fluidization — 6 Hours

Unit 4: Separation of solids from fluids: Introduction; Sedimentation: Free Settling, hindered settling, Richardson-Zaki equation, design of settling tanks; Filtration: concepts, bag filters, electrostatic filters, design offilters; Centrifugal separation, design of cyclones and hydro-cyclones; Colloidal particles: stabilization, flocculation. Filtration and its types, Filtration theory, Cake resistance, Batch and continuous filtration. 10 Hours

Unit 5: Introduction to nanoparticles: properties, characterization, methods of synthesis, applications 5 Hours

Text Books:

1. W. L. McCabe, J. C. Smith and P. Harriot, Unit Operations of Chemical Engineering (Intl Edn.), 7th Edition, McGraw Hill, New York, 2004
2. R. P. Chhabra and B. Gurappa, Coulson and Richardson's Chemical Engineering Vol 2A, Particulate Systems and Particle Technology, 6th Ed., Butterworth-Heinemann, 2019

Reference Books:

1. Brown G.G. and Associates, "Unit Operations", 1995, CBS Publishers.
2. Geankoplis C.J., Transport Processes and Separation Process Principles, 4th Ed., 2003, Prentice Hall.
3. Narayanan C.M. and Bhattacharya B.C., "Mechanical Operation for Chemical Engineers –Incorporating Computer Aided Analysis", 1992, Khanna Publishers.

CO/PO Mapping for the course:

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	-	-	-	-	-	-	-	-	-	-	3	3
CO2	3	3	3	-		-	-	-	-	-	-	-	3	3
CO3	3	3	3	-	3	-	-	-	-	-	-	-	3	3
CO4	3	3	-	-	-	-	-	-	-	-	-	-	3	3
Avg	3	3	3	-	3	-	-	-	-	-	-	-	3	3

CHCE 3105	**Mass Transfer Lab**	**L**	**T**	**P**	**C**
		0	**0**	**1**	**1**
Pre-requisites/Exposure	Mass transfer I				
Co-requisites					

Course Outcomes:

CO1. Illustrate fundamental knowledge in understanding the practical problem and finding the engineering solution.
CO2. Interpret the data obtained from the experiments and operate the equipment.
CO3. Solve the given problem using the correct chemical engineering principles and reporting with proper documentation.
CO4. Use teamwork and ethical principles in solving engineering problem with a measure to o overcome obsolescence.

Experiments List:

1. To plot Vapour Liquid Equilibrium curve for a given system.
2. To determine the solid-liquid equilibrium data for the given leaching system.
3. Study the solid liquid extraction operation in a bed extraction unit; calculate the percentage recovery of oil, and effect of solvent temperature and solvent rate.
4. Study the steam distillation process using turpentine oil as a feedstock, the vaporizing efficiency and percentage recovery of turpentine.
5. To study the absorption of carbon dioxide by aqueous sodium hydroxide in a packed bed absorption tower and to calculate the overall mass transfer coefficients and the number of transfer units and height of transfer units.
6. To study the performance of batch crystallizer and to calculate the yield and percentage recovery of crystals.
7. Evaluation of mass transfer coefficient in wetted wall column.
8. Adsorption in a packed bed for a solid-liquid system and to plot break through curve of adsorption and to calculate the unused bed.
9. Determination of the diffusion co-efficient of an organic vapour in air and to study the effect of temperature on diffusion co-efficient.
10. To study the drying characteristics of a solid material under batch drying condition and determination of drying rate and to plot moisture lost with time under for different operating conditions.

Reference Books:

1. Laboratory Manuals
2. R. E. Treybal, Mass Transfer Operations, 3rd Ed., McGraw Hill, New York, 1980.
3. J. D. Seader and E. J. Henley, Separation Process Principles, 2nd Ed., Wiley, New York, 2006

CO/PO Mapping for the course:

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	-	-	-	-	-	-	-	-	-	-	-	-	-
CO2	-	-	-	3	-	-	-	-	-	-	-	-	2	-
CO3	-	-	-	-	-	-	-	-	-	2	-	-	-	3
CO4	-	-	-	-	-	-	-	3	3	-	-	3	-	-
Avg	3	-	-	3	-	-	-	3	3	2	-	3	2	3

CHCE 3152	**Particulate Technology Lab**	**L**	**T**	**P**	**C**
		0	**0**	**1**	**1**
Pre-requisites/Exposure					
Co-requisites	**Particulate Technology**				

Course Outcomes:

CO1. Illustrate fundamental knowledge in understanding the practical problem and finding the engineering solution.
CO2. Interpret the data obtained from the experiments and operate the equipment.
CO3. Solve the given problem using the correct chemical engineering principles and reporting with proper documentation.
CO4. Use teamwork and ethical principles in solving engineering problem with a measure to o overcome obsolescence.

Experiments List:

1. To calculate the efficiency for grinding a material of known work index, the effect of RPM on the power consumption, the critical speed of ball mill.
2. To study the performance of a given cyclone and to study the effect of inlet gas velocity on overall efficiency.
3. To determine the terminal settling velocity of different particles in a fluid and plot CD as a function of Rep and to verify the validity of equation $CD = m(Rep)^n$.
4. To study the performance of Froth Flotation cell and to find the % recovery of mineral in froth from a standard.
5. To determine the effectives of the given screen
6. To analyze the various sizes of the given material of various sizes of mesh
7. To determine the efficiency of the Crusher for crushing a material of known working index.
8. To determine the minimum thickness area required for continuous thickening to 700 kg/m^3 underflow concentration for a feed rate of 1 m^3/min of slurry from batch sedimentation experiment.

Reference Books:

1. Laboratory Manuals
2. W. L. McCabe, J. C. Smith and P. Harriot, Unit Operations of Chemical Engineering (Intl Edn.), 7th Edition, McGraw Hill, New York, 2004
3. R. P. Chhabra and B. Gurappa, Coulson and Richardson's Chemical Engineering Vol 2A, Particulate Systems and Particle Technology, 6th Ed., Butterworth-Heinemann, 2019

CO/PO Mapping for the course:

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	-	-	-	-	-	-	-	-	-	-	-	-	-
CO2	-	-	-	3	-	-	-	-	-	-	-	-	2	-
CO3	-	-	-	-	-	-	-	-	-	2	-	-	-	3
CO4	-	-	-	-	-	-	-	3	3	-	-	3	-	-
Avg	3	-	-	3	-	-	-	3	3	2	-	3	2	3

SEMESTER VI

CHCE 3031	**Chemical Reaction Engineering II**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**
Pre-requisites/Exposure	Chemical Reaction Engineering I				
Co-requisites					

Course Objectives:

1. Understand non-ideality in real reactors and determine the deviation from ideality.
2. Develop models for non-ideal reactors
3. Assess complex chemical reaction mechanisms and kinetics.
4. To learn catalytic phenomena with extensions to reactor design and catalyst characterization.

Course Outcomes:

CO1. Understanding the fundamentals of non-ideal flow, RTD, dispersion, adsorption, heterogeneous reaction, catalysis and particle reaction kinetics.
CO2. Apply the different models to solve the chemical reaction engineering problems
CO3. Analyze the effect of process variables in the non-ideal reactor.
CO4. Evaluate the performance of non-ideal reactors
CO5. Design of non-ideal reactor based upon different models.

Course Descriptions:

Chemical Reaction Engineering-II focuses on heterogeneous and multi-phase reactors. Through understanding the underlying physics of the different reactor types, the student will be equipped to carry out reactor design tasks for conventional and novel reactors in a systematic way.

Course Curriculum:

Unit 1: Introduction to non-ideal flow; Residence Time Distribution (RTD); E and F distribution curves; Solution using MS Excel/Spreadsheets	12 Hours
Unit 2: Compartment models; Dispersion models; Tank-in-series model; Earliness of mixing, segregation and RTD; Solution using MS Excel/Spreadsheets	12 Hours
Unit 3: Catalysis and catalytic reactors: definition, properties and classification of catalyst, steps in a catalytic reactions, Synthesizing a rate law, Mechanism and rate limiting step.	9 Hours
Unit 4: Heterogeneous reactions- Introduction, Solid catalyzed reactions: The rate equation for surface kinetics, Pore diffusion resistance combined with surface kinetics, Porous catalyst particles, heat effects during reaction, experimental methods for finding rates, Deactivating catalysts, Mechanism of catalyst deactivation, The rate and performance equations.	9 Hours
Unit 5: Fluid particle reaction kinetics: catalytic reaction kinetic models	3 Hours

Text Books:

1. Octave Levenspiel, "Chemical Reaction Engineering", 3rd edition, John Wiley & Sons India edition, 2011
2. Scott Fogler. H., "Elements of Chemical Reaction Engineering", 3rd edition, Prentice Hall of India, New Delhi, 2006.

Reference Books:

1. Smith. J.M., "Chemical Engineering Kinetics", 3rd edition, McGraw Hill International Ed., New Delhi, 1981.
2. Ronald. W.Missen, Charles.A.Mions, Bradley.A.Saville, "Introduction to Chemical Reaction Operation and Kinetics", John Wiley and Sons, Singapore, 1999.

CO/PO Mapping for the course:

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	3	-	-	-	-	-	-	-	-	-	-	3	3
CO2	3	-	3	-	3	-	-	-	-	-	-	-	2	3
CO3	3	2	3	-	-	-	-	-	-	-	-	-	3	3
CO4	3	3	-	3	-	-	-	-	-	-	-	-	3	3
CO5	2	-	3	2	-	-	-	-	-	-	-	-	3	3
Avg	2.8	2.7	3	2.5	3	-	-	-	-	-	-	-	2.8	3

CHCE 3043	Process Equipment Design and Economics	L	T	P	C
		3	0	0	3
Pre-requisites/Exposure	Basic Chemical Engineering courses such as: Fluid Mechanics, Heat Transfer, Mass Transfer, Chemical Reaction Engineering, Process Control				
Co-requisites					

Course Objectives:

1. To enable students to know basic concepts in plant design and safety features in chemical engineering.
2. To help the students understand the technique of engineering economic analysis of a chemical plant.
3. To develop students' skills to develop a chemical process and perform a complete economic analysis of the plant
4. To enable students to appreciate the importance of safety in design and operation

Course Outcomes:

CO1. Understanding the basics of plant design, safety and economics.
CO2. Apply the design database for process creation.
CO3. Analyze the feasibility study and plant economics.
CO4. Evaluate the performance of different design approach
CO5. Design a plant with safety and profitability

Course Descriptions:

This course covers the important aspects of plant design and the basic economic analysis of a chemical plant. The objective of the course is to impart knowledge to the students about the basic concepts in plant design, safety considerations and engineering economic calculations in chemical engineering. By the end of the course, the students will be able to develop a chemical process and perform a complete economic analysis of the plant. It will enable the students to be aware of the importance of safety concepts and considerations in design and operation of a chemical plant.

Course Curriculum:

UNIT I: GENERAL DESIGN CONSIDERATIONS
Design codes; Design pressure; Design temperature; Design stress; materials; welded joint efficiencies; corrosion allowances; Design loads, liquid storage tank codes, classification, design of shell, bottom plates, self supported, and column supported roofs, wind girder, nozzles and other accessories.
UNIT II: PRESSURE VESSEL DESIGN
classification of pressure vessels, Design of cylindrical and spherical shell under internal and external pressures; Selection and design of flat plate, torispherical, ellipsoidal, and conical closures, compensations of openings. Stress analysis of thick walled cylindrical shell, Tall vertical & horizontal vessels: Pressure dead weight, wind, earthquake and eccentric loads and induced stresses; combined stresses, Shell design of skirt supported vessels. Vessel supports; Design of skirt, lug, and saddle supports.
UNIT III: EQUIPMENT DESIGN Shell and tube exchanger design: Construction details- Heat-exchanger standards and codes, Fluid allocation, Basic design procedure, Kern‟s method of rating, Kern‟s method of Sizing. Separation equipment design: Plate Contactors, Selection of Trays, Designing Steps of Distillation Column(Using F-U-G Correlations): Calculation of Minimum number of stages, Minimum Reflux Ratio, Actual Reflux Ratio, theoretical number of stages, actual number of stages, diameter of the column, weeping point, entrainment, pressure drop and the height of the column.

UNIT IV: COST ESTIMATION: Capital Investment, Time value of Money, Depreciation, Cost Elements, Unit Processing Cost, Estimation of Production cost and Revenues
UNIT V: PROFITABILITY: Profitability and Margins, Profitability Criteria, P&L Account, Taxes & Insurance.

Text Books:

1. Warren D. Seider, J. D. Seader, Daniel R. Lewin, Soemantri Widagdo, " Product and Process Design Principles: Synthesis, Analysis and Design", Third Edition, John Wiley & Sons, 2014

2. Guidelines for Engineering Design for Process Safety, Second Edition, Centre for Chemical Process Safety (CCPS), 2012
3. M.S. Peters and K. D. Timmerhaus, "Plant Design and Economics for Chemical Engineers", Fourth Edition, McGraw Hill International Book Co., 1991

Reference Books:

1. James R. Cooper, "Process Engineering Economics", Marcel Delkker Inc, New York, 2003
2. Coulson, J.M., Richardson J.E. and Sinnott R.K., "Chemical Engineering", Vol. VI, Pergamon Press, 1991
3. R. Turton, R. C. Bailie, W. B. Whiting, and J. A. Shaeiwitz, "Analysis, Synthesis, and
4. Design of Chemical Processes", Prentice Hall, Upper Saddle River, New Jersey, 1998

CO/PO Mapping for the course:

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	-	-	2	-	2	3	-	2	2	-	2	-	-
CO2	-	3	2	-	3	-	-	-	2	-	-	2	3	3
CO3	-	-	2	-	-	-	3	-	2	-	-	2	-	-
CO4	3	-	-	2	3	-	-	-	2	-	3	2	3	3
CO5	3	3	2	-	-	2	-	-	2	2	3	2	3	3
Avg	3	3	2	2	3	2	3	-	2	2	3	2	3	3

CHCE 3007	**Process Dynamics, Instrumentations and Controls**	**L**	**T**	**P**	**C**
		3	**1**	**0**	**4**
Pre-requisites/Exposure	Mathematics, Physics, Thermodynamics, Heat transfer, Fluid flow, Mass transfer and Reaction engineering				
Co-requisites					

Course Objectives:

1. To equip the students with the knowledge of modelling a physical process
2. To understand the various control schemes
3. To analyze the dynamic response of a physical process
4. To apply the control system in various processes

Course Outcomes:

CO 1 Understanding the basics of process dynamics, control system and instrumentation.
CO 2 Solve the process dynamics and control problems using modern engineering tools.
CO 3 Analyze the process stability using different methods
CO 4 Evaluate the process dynamic and stability using different controller tuning strategies.
CO 5 Design of a control system for a stable process

Course Descriptions:

This course introduces students to dynamic modeling, modern practice and industrial technology of process control and instrumentation, combining theoretical and computational approaches in order to illustrate how dynamic mass and energy balances govern the response of physical processes and plants to the set point changes and the external load disturbances.

Course Curriculum:

Unit 1: Process Dynamics of simple first order systems - Control Loop and its Elements; Basics of Laplace Transform to solve differential equation; Basics of Process Dynamics; Transfer function; Development of dynamic model for first order systems; Dynamic Responses and its analysis of first order system for different forcing functions. 8+3 Hours

Unit 2: Process Dynamics of Complex Systems - Interacting and Non-Interacting systems in series; Linearization of nonlinear systems; Dynamics of second order system and transportation lag 9+3Hours

Unit 3: Control System and Stability - Basics of Control System and its element; Overall transfer function; Final control element; Controller: P, PI, PD and PID controller, Response of control system with these controllers; Definition of stability; Criteria of Stability; Routh's Test, Root Locus Method. 12+3 Hours

Unit 4: Frequency Response and Design of controllers - AR and phase lag by frequency response; Bode Diagram (BD) of first order, second order systems and transportation lag; BD of P, PI, PD and PID Controller; BD of simple control system, Corner frequency, crossover frequency, phase margin, Gain margin, Ziegler Nichols controller tuning settings; Selection of controllers; Controller tuning by minimizing error functions; Controller tuning by experimental methods, Ziegler Nichols and Cohen Coon Method 12+4 Hours

Unit 5: Instrumentation - Typical function of instruments; Static and dynamic characteristics of instrument; Dynamics of Final control element; Selection and working of measuring elements; Temperature; Pressure; Flow; level and Concentration 4+2 Hours

Text Books:

1. Coughanowr, D. R., LeBlanc, S. " Process Systems Analysis and Control" , 3rd edition, McGraw-Hill (2008).

Reference Books:

1. Seborg, D.E., Edgar, T.F., Mellichamp, D.A. "Process Dynamics and Control", 2nd edition, John Wiley (2003)
2. Stephanopoulos, G. " Chemical Process Control: An Introduction to Theory and Practice", Pearson Education (1984)

CO/PO Mapping for the course:

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	3	1	-	-	-	-	-	-	1	3	3
CO2	3	2	3	3	2	-	-	-	-	-	-	1	3	3
CO3	3	3	3	3	3	-	-	-	-	-	-	1	3	3
CO4	3	3	3	3	3	-	-	-	-	-	-	1	3	3
CO5	3	3	3	3	2	-	-	-	-	-	-	1	3	3
Avg	3	3	3	3	2	-	-	-	2	-	-	1	3	3

CHCE 3139	Chemical Reaction Engineering Lab	L	T	P	C
		0	0	1	1
Pre-requisites/Exposure					
Co-requisites					

Course Outcomes:

CO 1 Illustrate fundamental knowledge in understanding the practical problem and finding the engineering solution.
CO 2 Interpret the data obtained from the experiments and operate the equipment.
CO 3 Solve the given problem using the correct chemical engineering principles and reporting with proper documentation.
CO 4 Use teamwork and ethical principles in solving engineering problem with a measure to overcome obsolescence.

Experiment List:

1. To plot the residence time distribution (RTD) curve for a plug flow tubular reactor (PFTR) using a pulse tracer – To calculate dispersion number.
2. To plot the residence time distributions (RTD) curve for a CSTR using a pulse tracer – To calculate dispersion number.
3. To determine the reaction rate constant (k) for the given saponification reaction of ethyl acetate in aqueous sodium hydroxide solution.
4. To determine the order and value of the rate constant for the liquid reaction of caustic soda and ethyl acetate in a batch reactor.
5. To determine the value of the rate constant and rate equation for the liquid reaction of caustic soda and ethyl acetate in a continuous stirred tank reactor.
6. To determine the value of the rate constant and rate equation for the liquid reaction of caustic soda and ethyl acetate in stirred tank reactors in series.
7. Study the effect of flow rate on the conversion of acid base reaction (Sodium hydroxide and Ethyl acetate (EA).
8. To calculate the first order rate constant for the photo catalytic oxidation of formic acid.
9. To study a non-catalytic homogeneous reaction in a series arrangement of PFR and CSTR.
10. To study the characteristics of mixed biological reactor and the stoichiometry and kinetics of aerobic biological processes.

Reference Books:

1. Laboratory Manuals
2. Octave Levenspiel, "Chemical Reaction Engineering", 3rd edition, John Wiley & Sons India edition, 2011
3. Scott Fogler. H., "Elements of Chemical Reaction Engineering", 3rd edition, Prentice Hall of India, New Delhi, 2006.

CO/PO Mapping for the course:

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	-	-	-	-	-	-	-	-	-	-	-	-	-
CO2	-	-	-	3	-	-	-	-	-	-	-	-	2	-
CO3	-	-	-	-	-	-	-	-	-	2	-	-	-	3
CO4	-	-	-	-	-	-	-	3	3	-	-	3	-	-
Avg	3	-	-	3	-	-	-	3	3	2	-	3	2	3

CHCE 3149	Testing and Analysis Lab	L	T	P	C
		0	0	1	1
Pre-requisites/Exposure					
Co-requisites					

Course Outcomes:

CO1. Illustrate fundamental knowledge in understanding the practical problem and finding the engineering solution.
CO2. Interpret the data obtained from the experiments and operate the equipment.
CO3. Solve the given problem using the correct chemical engineering principles and reporting with proper documentation.
CO4. Use teamwork and ethical principles in solving engineering problem with a measure to o overcome obsolescence.

Experiments List:

1. To determine the aniline point of the given petroleum product
2. To determine the distillation range of the given sample at atmospheric pressure.
3. To determine the cloud point and pour point of the given sample.
4. To determine the drop point of the given sample.
5. To determine the flash and fire point of given samples.
6. To determine the Kinematic Viscosity of the given sample of oil at various temperatures and to study corresponding variation with respect to temperature.
7. To determine the Reid Vapor Pressure of the given sample and for the determination of vapor pressure of volatile non viscous petroleum products.
8. To study the performance of batch crystallizer and to calculate the yield and percentage recovery of crystals.
9. Evaluation of mass transfer coefficient in wetted wall column.
10. Adsorption in a packed bed for a solid-liquid system and to plot break through curve of adsorption and to calculate the unused bed.

Reference Books:

1. Laboratory Manuals
2. Rao, BK Bhaskara. Modern petroleum refining processes. Oxford & IBH Publishing, 2007.
3. Sarkar, Samir. Fuels and combustion. Universities Press, 1974.
4. Nelson, W. L. "Petroleum Refining Engineering, 1941.
5. Gary, James H., Glenn E. Handwerk, and Mark J. Kaiser. Petroleum refining: technology and economics. CRC press, 2007.

CO/PO Mapping for the course:

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	-	-	-	-	-	-	-	-	-	-	-	-	-
CO2	-	-	-	3	-	-	-	-	-	-	-	-	2	-
CO3	-	-	-	-	-	-	-	-	-	2	-	-	-	3
CO4	-	-	-	-	-	-	-	3	3	-	-	3	-	-
Avg	3	-	-	3	-	-	-	3	3	2	-	3	2	3

SEMESTER VII

CHCE 4017	**Transport Phenomena**	**L**	**T**	**P**	**C**
		3	**1**	**0**	**4**
Pre-requisites/Exposure	Mass Transfer; Heat Transfer; Momentum Transfer; Chemical Reaction Engineering				
Co-requisites					

Course Objectives:

1. To envision real life chemical engineering processes as a combination of mass, momentum and energy transfer process
2. To be able to develop the governing equations for the said processes
3. To be able to design chemical engineering equipments using the transport equations

Course Outcomes:

CO1: Understanding the concept of mass, momentum and energy transport.
CO2: Apply the transport phenomena principles to solve the problems using modern engineering tools.
CO3: Analyze the mass, momentum and energy transport behavior in different systems.
CO4: Evaluate the effect of process variables on transport phenomena in a chemical engineering problem.

Course Descriptions:

This course will highlight the coupling between three transport phenomena with applications in various disciplines in engineering and science, and will demonstrate to the students the common mathematical structure of transport problems. The course will deal with flow problems involving Newtonian and non-Newtonian fluids, solid-state heat conduction, forced and free convection, binary diffusion with or without chemical reaction

Course Curriculum:

Unit 1: Momentum Transfer – Introduction to Transport Phenomena; Mechanism of momentum transport; Shell momentum balance; Flow of a falling film; Flow through circular tube; Flow through an annulus; Equation of motion for isothermal systems; Macroscopic balance for isothermal flow systems; Friction Factors; Dimensional Analysis; Turbulent flow.	22+8 Hours
Unit 2: Energy Transfer – Introduction to energy transfer; Shell Energy balance in solid and laminar; Equation of heat transfer for non-isothermal systems; Macroscopic balance for non-isothermal systems;	14+4 Hours
Unit 3: Mass Transfer – Introduction to mass transfer; Concentration distributions in solid and laminar; Equation of heat transfer for non-isothermal systems;	8+4 Hours

Text Books:

1. R. B. Bird, W. E. Stewart, and E. S. Lightfoot. Transport Phenomena, 2nd ed., Wiley India Pvt. Ltd., 2002.

Reference Books:

1. Vijay Gupta and Santosh K. Gupta, Fluid Mechanics and its Applications, 3rd ed., New Age International Publishers, New Delhi, 2016.
2. Vijay Gupta, Elements of Heat and Mass Transfer, New Age International Publishers, New Delhi, 1995.
3. Welty, C. E. Wicks, R. E. Wilson, and G. L. Rorrer, Fundamentals of Momentum, Heat and Mass Transfer, 5th ed., Wiley India Pvt. Ltd., 2007.
4. W. J. Thompson, Introduction to Transport Phenomena, Prentice Hall, 2000.

CO/PO Mapping for the course:

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	2	-	-	-	-	-	-	-	-	3	3
CO2	3	3	3	2	-	-	-	-	-	-	-	-	3	3
CO3	3	3	3	2	-	-	-	-	-	-	-	-	3	3
CO4	3	3	3	2	-	-	-	-	-	-	-	-	3	3
Avg	3	3	3	2	-	-	-	-	-	-	-	-	3	3

CHCE 4118	Design and Simulation Lab	L	T	P	C
		0	0	2	2
Pre-requisites/Exposure					
Co-requisites					

Course Outcomes:

CO 1 Illustrate fundamental knowledge in understanding the practical problem and finding the engineering solution.
CO 2 Interpret the data obtained from the experiments and operate the equipment.
CO 3 Solve the given problem using the correct chemical engineering principles and reporting with proper documentation.
CO 4 Use teamwork and ethical principles in solving engineering problem with a measure to overcome obsolescence.

Experiments List

1. Introduction to ASPEN Environment
2. ASPEN Simulation for mixing and separation
3. ASPEN Simulation using reactors
4. ASPEN Simulation for chemical process using columns and pressure changers
5. ASPEN Simulation for Heat exchangers
6. Design Specification and Sensitivity Analysis using ASPEN
7. Introduction to PROsim
8. Steady state simulation using PROsim
9. Dynamic Simulation using PROsim
10. Dynamic process simulation using PROsim

Reference Books:

1. Laboratory Manuals
2. ASPEN manuals/user guide
3. PROSIM manuals/user guide

CO/PO Mapping for the course:

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	-	-	-	3	-	-	-	-	-	-	-	-	-
CO2	-	-	-	3	3	-	-	-	-	-	-	-	2	-
CO3	-	-	-	-	3	-	-	-	-	2	-	-	-	3
CO4	-	-	-	-	3	-	-	3	3	-	-	3	-	-
Avg	3	-	-	3	3	-	-	3	3	2	-	3	2	3

CHCE 4119	**Instrumentations and Controls Lab**	**L**	**T**	**P**	**C**
		0	**0**	**1**	**1**
Pre-requisites/Exposure					
Co-requisites					

Course Outcomes:

CO 1 Illustrate fundamental knowledge in understanding the practical problem and finding the engineering solution.
CO 2 Interpret the data obtained from the experiments and operate the equipment.
CO 3 Solve the given problem using the correct chemical engineering principles and reporting with proper documentation.
CO 4 Use teamwork and ethical principles in solving engineering problem with a measure to overcome obsolescence.

Experiments List

1. Single Tank System: To study the dynamic response of liquid level in single tank.
2. Two tank non-interacting system: To study the dynamic response of two tank non-interacting system
3. Two Tank Interacting System: To study the dynamic response of two tank interacting system
4. Calibration of Pressure transmitter system
5. Thermocouple trainer: (a) Calibration of thermocouple (b) Determine time constant of thermocouple
6. Dead weight pressure gauge: Calibration of Pressure gauge by dead weight piston
7. Control valve characteristics:(a) To study installed characteristics of linear control valve (b) To study installed characteristics of equal % control valve
8. Flow control trainer:(a) To study the open loop or manual control (b) To study the proportional control (c) To study the two mode (P+I) control (d) To study the two mode (P+D) control (e) To study the three mode (PID) control
9. Temperature control trainer:(a) To study the open loop or manual control (b) To study the proportional control (c) To study the two mode (P+I) control (d) To study the two mode (P+D) control (e) To study the three mode (PID) control
10. Level control trainer:(a) To study the open loop or manual control (b) To study the proportional control (c) To study the two mode (P+I) control (d) To study the two mode (P+D) control (e) To study the three mode (PID) control
11. Pressure control trainer:(a) To study the open loop or manual control (b) To study the proportional control (c) To study the two mode (P+I) control (d) To study the two mode (P+D) control (e) To study the three mode (PID) control

Reference Books:

1. Laboratory Manuals
2. Coughanowr, D. R., LeBlanc, S. " Process Systems Analysis and Control" , 3rd edition, McGraw-Hill (2008).

CO/PO Mapping for the course:

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	-	-	-	-	-	-	-	-	-	-	-	-	-
CO2	-	-	-	3	-	-	-	-	-	-	-	-	2	-
CO3	-	-	-	-	-	-	-	-	-	2	-	-	-	3
CO4	-	-	-	-	-	-	-	3	3	-	-	3	-	-
Avg	3	-	-	3	-	-	-	3	3	2	-	3	2	3

SPECIALIZATIONS

CHCE 3010P	**Petroleum Refining Technology**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**
Pre-requisites/Exposure	Basic Chemistry, Thermodynamics, Heat Engines, Heat and Mass Transfer				
Co-requisites					

Course Objectives:

1. To give an overview of petroleum and petroleum refinery.
2. To provide understanding of applying separation processes to petroleum for obtaining various distillates and products.
3. To give insight into chemical processes to process the distillates into saleable products to meet ever changing product specifications.
4. To prepare the students for the emerging refining trends viz. co-processing, biofuels and blending.

Course Outcomes:

CO1 Understanding the basic concept of reefing processes

CO2 Sketch the diagrams for different refining process

CO3 Differentiate and compare the different process use in the petroleum industry.

CO4 Critique the different refining process in the modern refinery

Course Descriptions:

Petroleum accounts for 34% of world primary energy consumption, particularly provides transportation fuels and feedstock for petrochemicals. Due to ever changing fuel specifications and to address sustainability, petroleum refining processes are continuously upgraded. This course aims at providing the origin, composition and types of crude oil so that awareness about processes mimicking the natural formation of petroleum is inculcated. Further entire spectrum of basic separation, conversion and finishing processes of petroleum to finished fuels is covered. As the automobile population booms so also the demand for lubricants and hence production of lube base from crude and finishing processes are to be dealt in detail. Keeping in view of greenhouse gas emission and energy security concern, co-processing of waste biomass streams to produce alternate fuels, biofuels and blends are to be introduced.

Course Curriculum:

CRUDE OIL & REFINIERY OVERVIEW 10 h
Origin, availability, composition, classification, properties, crude assay, specifications and test methods - Overview of refinery.

REFINING PROCESSES 8 h
Separation processes- Desalting, atmospheric distillation, Vacuum distillation, Deasphalting, Dewaxing

Conversion Processes-Thermal Processes - Thermal cracking, Vis-breaking, Coking 8 h
Catalytic Processes-Catalytic Cracking, Hydrocracking, Reforming, Alkylation, Polymerizaion Isomerization,

Finishing Processes Hydrotreatment - Hydrodesulphurization, Hydrodenitrogenation- Product blending. 6 h

Lube Oil Base Stock Production, Classification and Characterization - Propane Deasphalting, Dewaxing, Hydro –Finishing. 6 h

NEW TRENDS IN PETROLEUM REFINING 7 h
Co-processing of renewable feeds – Co-processing of lipids and bio-oil in hydroprocessing and FCC units. IH^2 technology for municipal solid waste to auto fuels – Hydrothermal liquefaction of sewage sludge integrated with hydroprocessing to auto fuels. Alternate fuels - Biofuels -Blending with petroleum derived fuels.

Text Books:

1. I D Mall, Petroleum Refining Technology, CBS Publishers & Distributors, 2017.
2. Ram Prasad, Petroleum Refining Technology, Khanna Publishers, 1998.
3. G. N. Sarkar, Advanced Petroleum Refining, Khanna Publishers, 1996.
4. Bhaskara Rao, Modern Petroleum Refining Processes, Oxford & IBH Publishing, 2018.

Reference Books:

1. James G Speight, Handbook of Petroleum Refining, CRC Press, 2017.
5. Robert A. Meyers, Handbook of Petroleum Refining Processes, Fourth Edition, McGraw-Hill Education, 2016.
6. David S. Jones and Peter R. Pujadó, Handbook of Petroleum Processing, Springer, 2006
7. Surinder Parkash, Refining Processes Handbook, Elsevier Science, 2003.

CO/PO Mapping for the course:

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1														
CO2	3	3	3										3	
CO3	3	3	3										3	
CO4	3	3	3										3	
Avg	3	3	3				3						3	

CHCE 3021	Chemical Process – Carbon Black	L	T	P	C
		3	0	0	3
Pre-requisites/Exposure	Basic Engineering Mathematics, Fluid Mechanics, Thermodynamics, Heat Transfer and Mass Transfer				
Co-requisites					

Course Objectives:

1. To help the students to understand the basic process in the manufacture of Carbon Black
2. To enable students to interact with the industry personnel to enhance their basic concepts
3. To help students to understand the feed composition and other process equipments along with their operations in Carbon Black Industries
4. To encourage students to design innovative technology to enhance the yield of Carbon black

Course Outcomes:

CO1. Understand the basic concepts of carbon black production
CO2. Implement the fundamental concepts in defining the process parameters
CO3. Analyse the real-time data of the industry for improvement
CO4. Evaluate the effect of process parameters on the process reliability

Course Descriptions:

This course is completely industry run course by Phillips Carbon Black Limited, PCBL, as an industry academia interaction. The students will go through this course for better understanding of polymer technology, application of carbon black in rubber and non-rubber industrial products. This course covers topics from market for carbon black, raw materials, process equipments, its design and operations, safety and trouble shooting.

Course Curriculum:

Unit 1: Introduction and Materials - Carbon Black Industry global overview and marketing; Feedstock, additives, Packaging materials — 8 Hours

Unit 2: Process and Instrumentation - Reactor and System Operation, Bag filter system, conveying system and operations, Palletization, Dryer System, Conveying Carbon Black to Silo, Utilities, Project engineering and maintenance — 20 Hours

Unit 3: Product - Quality, Applications in various sectors like rubber and non-rubber industries — 14 Hours

Unit 4: Safety and Quality standards - Safety and Health standards, Process Reliability and Quality standards and Quality control tools — 3 Hours

Text Books:

1. Industrial Notes and references from Phillips Carbon Black Limited, PCBL

CO/PO Mapping for the course:

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	-	3	-	-	-	-	-	-	-	2	-	3	3
CO2	-	3	-	3	-	-	2	-	-	-	-	-	3	3
CO3	3	3	3	3	-	-	2	-	-	-	2	-	3	3
CO4	3	3	3	3	-	-	2	-	-	-	2	-	3	3
Avg	3	3	3	3	-	-	2	-	-	-	2	-	3	3

CHCE 3044P	**Petrochemical Processing Technology**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**
Pre-requisites/Exposure	Environmental Science, General Chemical Technology				
Co-requisites					

Course Objectives:

4. To provide the basic concepts of petrochemicals.
5. To give an understanding about the mechanism and kinetics of important petrochemical processes.
6. To explain the process technology for the manufacture of different petrochemicals, plastics, rubber and fibers.
7. To provide an insight into the integration of refinery operation with petrochemicals production.

Course Outcomes:

CO1 Understand the basics of petrochemicals and the scenario of petrochemical industry in India.

CO2 Sketch the process flow diagrams involved in petrochemical production.

CO3 Analyze the process flow diagrams for first, second, and third generation petrochemical industry

CO4 Critique the different process technology used in process technology

Course Descriptions:

Petrochemical industry is almost a trillion dollar industry and much of future expansion will happen in BRICS nations. It touches every day's life in the form of fertilizers, plastics, fibers and elastomers and their manufacturing involves applications of principles of chemical engineering. This course provides the basic concepts of petrochemicals, kinetics and mechanism of different petrochemical processes and process technology of their manufacture.

Course Curriculum:

INTRODUCTION TO PETROCHEMICALS 8 h

Introduction to Petrochemicals, Classification, Structure of petrochemical industry – Choice of feedstock - Global and national perspective of Petrochemical Industry- Safety Hazards and mitigation.

FIRST GENERATION PETROCHEMICAL PROCESSES 10 h

Synthesis Gas – Syngas derivatives - Ammonia, Methanol.
Olefins Production – Steam cracking – FCC - Catalytic Dehydrogenation
Aromatics Production - Catalytic reforming – Miscellaneous processes

SECOND GENERATION PETROCHEMICAL PROCESSES 10 h

Olefins Derivatives – Ethylene oxide, Vinyl chloride, acrylonitrile
Aromatics derivatives – Phthalic anhydride, Terephthalic acid, Phenol, Cyclohexane, Styrene, Toluene Di-isocyanate, Linear Alkyl Benzene
Methanol Derivatives: Acetic Acid, Methyl Methacrylate, Chloromethane.

THIRD GENERATION PETROCHEMICAL PROCESSES 8 h

Thermosetting and Engineering Resins, Synthetic Fibers, Synthetic Rubber. Detergents, Fertilizers, Pesticides, Dyes, Drugs

REACTION MECHANISM AND KINETICS OF PETROCHEMICAL PROCESSES 4 h

Steam Cracking, Catalytic Reforming, Polymerization, Alkylation

EMERGING TRENDS IN PETROCHEMICALINDUSTRY 5 h

Integration of Petrochemical production with Refinery operations – Sustainable Petrochemical production from renewable resources – Production of Sustainable chemicals as substitute for petrochemicals.

Text Books:

1. I D Mall, Petrochemical Process Technology, Second Edition 2017, Laxmi Publications Private Limited.
2. B.K.Bhaskararao, A Text on petrochemicals, Fifth Edition, Second Reprint 2015, Khanna Publishers,
3. C.R.Lahiri and D.Biswas, Petrochemical Industries: Technology and Processes, 2010, CBS Publishers & Distributors.

4. Saikat Maitra and O. P. Gupta, Elements of Petrochemical Engineering, 2018, Khanna Publishing.

Reference Books:

1. G. Margaret Wells, Handbook of Petrochemicals and Processes, Second Edition 1999, Gower Publishing Ltd.
2. N Naderpour, Petrochemical Production Processes, 2009, SBS Publishers and Distributors Pvt Ltd.
3. G.N. Sarkar, Advanced Petrochemicals, First edition, 2002, Khanna Publishers.
4. Robert A. Meyers, Handbook of Petrochemicals Production Processes, First edition, 2005 McGraw-Hill Education.

CO/PO Mapping for the course:

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	-	-	2	-	-	-	-	-	-	-	-	-	-
CO2	3	3	-	2	-	-	1	-	-	-	-	-	-	3
CO3	3	3	3	-	-	2	2		-	1	-	-	3	1
CO4	3	3	3	-	-	-	2		-	1	-	-	3	1
Avg	3	3	3	2	-	1.5	1.75		-	1	-	1	3	1.5

CHCE 4025P	**Catalyst Design and Catalysis**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**
Pre-requisites/Exposure	Basic knowledge in Chemical Reaction Engineering				
Co-requisites					

Course objectives:

1. To explain the principles of catalysis and its importance.
2. To describe the mechanism of petroleum refining and petrochemical processes and lay the principles for designing the catalysts.
3. To explain the methods of physico-chemical characterization of catalysts.
4. To introduce the various steps involved in the manufacture of catalysts.
5. To give the glimpse of emerging trends in catalysis and catalysts.

Course Outcomes:

CO1	Understanding the basic principles of catalysts and catalysis
CO2	Apply the concepts of catalysis in petroleum refining and petrochemical process development.
CO3	Analyze the effect of physico-chemical variables in catalysts performance
CO4	Evaluate the development of novel catalyst for waste to wealth transformation

Course Descriptions:

Catalysis is the corner stone of petroleum refining, petrochemicals and chemical processing industries. Designing a chemical process itself critically depends on the catalyst performance and typical example is fluidized catalytic cracking opened up new areas like fluidization. Concern for environment necessitating stringent specification for auto fuels and process modification demands continuous effort in catalyst improvement. Therefore, having an understanding of catalyst and catalysis is of key importance to be a successful chemical engineer. This course will provide the understanding of basic concepts of catalysis and the active centers for various processes employed in refining and petrochemical industries. It offers various physico-chemical characterization techniques for catalysts and enable to relate them with activity and selectivity of catalysts. It imparts knowledge on various unit operations and processes used in the general manufacture of industrial catalysts with specific emphasis for refining and petrochemical industries.

Course Curriculum:

Catalysis General Concepts

Definition – Types – Catalyst cycle- General Mechanism of homogeneous and heterogeneous catalytic reactions – Influencing factors - Importance of catalysis in chemical processes. 10 h

Catalysis in Petroleum Refining, Petrochemical and fine chemicals Industry

Mechanism of refining processes – cracking, reforming, isomerization, alkylation, hydrotreating, hydrocracking – Mechanism of petrochemical and fine chemical processes – oxidation – aromatic alkylation – esterification- Active centres 8 h

Assembly of solid catalyst

Methods of preparation of support – Incorporation of catalytically active components - shaping – drying – calcination – Manufacturing schemes of catalysts for refining petrochemical and fine chemical industries. 12 h

Catalyst Characterization

Overview of characterization techniques – composition – structure – textural – morphology - chemisorption – surface characterization techniques – catalytic activity 8 h

New & Emerging trends

Fuels and chemicals from renewable sources – Waste to wealth processes – Development of novel catalysts. 7 h

Text Books:

1. Applied heterogeneous catalysis: Design-manufacture use of solid catalysts by J.F.LE PAGE, Technip Editions
2. Concepts of Modern Catalysis and Kinetics by I. Chorkendorff and J.W. Niemantsverdriet, WILEY-VCH Verlag GmbH & Co
3. Catalysis Principles and Applications by B.Viswanathan, S.Sivasanker and A.V.Ramaswamy, Narosa Publishing House.

Reference Books:

1. Catalyst Preparation: Science and Engineering Edited by John R. Regalbuto, CRC Press Taylor & Francis Group
2. Thermal and Catalytic Processes in Petroleum Refining by Serge Raseev, Taylor & Francis Group
3. Principles of Catalyst Development by James T. Richardson, Springer US.
4. Nanostructured Catalysts edited by Susannah L. Scott, Cathleen M. Crudden and Christopher W. Jones, Kluwer Academic Publishers.

CO/PO Mapping for the course:

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	-	3	3	-	2	3		2	-	-	-	3	2
CO2	3	3	3	3	-	2	3		2	-	2	-	3	2
CO3	3	3	3	-	2	2	-		2	-	2	-	3	2
CO4	3	3	3	-	2	2	-	-	2	1	2	2	3	2
Avg	3	3	3	3	2	2	3		2	1	2	2	3	2

CHGS 3132P	**Process Modelling, Simulation, and Optimization**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**
Pre-requisites/Exposure	Heat and Mass Transfer, Chemical Reaction Engineering, Fluid Mechanics, Engineering mathematics				
Co-requisites	Chemical Engineering Computing				

A. Course Objectives

1. Exhaustive deliberations of the formulation and Simulation/Computations for Chemical Engineering Problems.
2. To dwell intensely with the conservation equations of mass and heat transfer from fundamental concepts applicable to Chemical Engineering.

B. Course Outcomes

On completion of this course, the students will be able to

CO1. Classify various mathematical models, and select the necessary simulation and optimization methodology to study chemical engineering processes.
CO2. Apply the conservation principles and develop mathematical models for fluid flow, heat and mass transfer, reaction operations and their equipment.
CO3. Apply various computational methods to simulate the dynamics and behaviour of various fluid flow, heat and mass transfer operations, reactions, process equipment and flow sheet.
CO4. Select the optimization techniques and apply it to solve various chemical engineering problems
CO5. Utilize commercial software to simulate and obtain optimized solutions to various chemical engineering problems.

C. Catalogue Description

UNIT I: INTRODUCTION

Introduction to modeling, simulation and optimization, classification of mathematical models, fundamental laws of chemical engineering system, Role and importance of steady-state and dynamic simulation, Model building, Modeling difficulties, Degree-of-freedom analysis.

UNIT II: MODELLING OF CHEMICAL ENGINEERING OPERATIONS

Batch and semi-batch reactors modelling, modeling of constant and variable holdup CSTRs under isothermal and non-isothermal conditions, Stability analysis of model, Gas phase pressurized CSTR, Two phase CSTR, Non-isothermal PFR, Bioreactors modelling, Steady state heat conduction, Single effect and multiple effect evaporator, Ideal binary distillation column, Single stage and two stage solvent extraction, Laminar flow of Newtonian and non-Newtonian fluid in a pipe, Gravity flow tank

UNIT III: PROCESS SIMULATION

Solution of models and simulation of equipment, Data fitting and regression using excel, Parameter estimation, Sequential modular approach, Equation oriented approach, Process simulation software for flow sheet simulation.

UNIT IV: PROCESS OPTIMIZATION

One-dimensional unconstrained optimization (Golden section search, Parabolic interpolation, Newon's Method), Multi-dimensional unconstrained optimization (Direct Methods and gradient methods),

Constrained optimization (Lagrangian multiplication method, Conjugate gradienr method, Powell's method).

D. Table: Correlation of POs, PSOs v/s COs

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	2									3	3
CO2	3	3	3	3									3	3
CO3	2	3	3	3									3	3
CO4	3	3	3	3									3	3
CO5	2	2	2	3	3								3	3

1. WEAK 2. MODERATE 3. STRONG

TEXT BOOK:

- Luyben W.L., Process Modeling, Simulation, and Control for Chemical Engineering, McGraw-Hill (1998).
- Chapra S.C. and Canale R.P., Numerical Methods for Engineers, McGraw Hill (2001).
- Bequette B.W., Process Dynamics: Modelling, Analysis and Simulation, Prentice Hall (1998).
- Denn M., Process Modelling, Wiley, New York (1986).
- Babu B.V., Process Plant Simulation, Oxford University Press (2004).
- Jana A.K., Chemical Process Modeling and Computer Simulation, PHI Learning Ltd (2012).

REFERRENCE BOOKS:

- Himmelblau D.M. and Bischoff K.B., Process Analysis and Simulation, Wiley (1988).

  Verma A.K., Process Modelling and Simulation in Chemical, Biochemical and Environmental Engineering, CRC Pres (2015).

CHGS 3131P	**Process Design and Intensification**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**
Pre-requisites/Exposure	Mathematics; Numerical Methods in Chemical Engineering				
Co-requisites	Chemical Engineering Computing				

A. Course Objectives

This course will enable the students:

1. To provide an understanding of the concept of Process Intensification.
2. To provide knowledge and understanding of application of intensification techniques to a range of processes e.g. heat and mass transfer, separation processes.
3. To provide an understanding of basic operating principles of a variety of intensified process equipment such as spinning disc reactor, rotary packed beds, oscillatory flow reactors, compact heat exchangers and micro-reactors etc.

B. Course Outcomes:

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

CO1 Explain the concept of Process Intensification and the methodologies for PI.

CO2 Summarize the benefits of PI in the process industries.

CO3 Relate the operating principles of several intensified technologies.

CO4 Analyse the range of potential applications of intensified equipment.

C. Catalogue Description

Unit I:

Introduction: Techniques of Process Intensification (PI) Applications, The philosophy and opportunities of Process Intensification, Main benefits from process intensification, Process Intensifying Equipment, Process intensification toolbox, Techniques for PI application.

Unit II:

Process Intensification through micro reaction technology: Effect of miniaturization on unit operations and reactions, Implementation of Micro reaction Technology, From basic Properties to Technical Design Rules, Inherent Process Restrictions in Miniaturized Devices and Their Potential Solutions, Microfabrication of Reaction and unit operation Devices - Wet and Dry Etching Processes.

Unit III:

Scales of mixing, Flow patterns in reactors, Mixing in stirred tanks: Scale up of mixing, Heat transfer. Mixing in intensified equipment, Chemical Processing in High-Gravity Fields Atomizer Ultrasound Atomization, Nebulizers, High intensity inline MIXERS reactors Static mixers, Ejectors, Tee mixers, Impinging jets, Rotor stator mixers, Design Principles of static Mixers Applications of static mixers, Higee reactors.

Unit IV:

Combined chemical reactor heat exchangers and reactor separators: Principles of operation; Applications, Reactive absorption, Reactive distillation, Applications of RD Processes, Fundamentals of Process Modelling, Reactive Extraction Case Studies: Absorption of NOx Coke Gas Purification. Compact heat exchangers: Classification of compact heat exchangers, Plate heat exchangers, Spiral heat exchangers, Flow pattern, Heat transfer and pressure drop, Flat tube-and-fin heat exchangers, Microchannel heat exchangers, Phase-change heat transfer, Selection of heat exchanger technology, Feed/effluent heat exchangers, Integrated heat exchangers in separation processes, Design of compact heat exchanger - example.

Unit V:

Enhanced fields: Energy based intensifications, Sono-chemistry, Basics of cavitation, Cavitation Reactors, Flow over a rotating surface, Hydrodynamic cavitation applications, Cavitation reactor design, Nusselt-flow model and mass transfer, The Rotating Electrolytic Cell, Microwaves, Electrostatic fields, Sono-crystallization, Reactive separations, Supercritical fluids.

D. Table: Correlation of POs, PSOs v/s COs

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	2									3	3
CO2	3	3	3	3									3	3
CO3	2	3	3	3									3	3
CO4	3	3	3	3									3	3
CO5	2	2	2	3	3								3	3

2. WEAK 2. MODERATE 3. STRONG

Textbooks:

11. Stankiewicz, A. and Moulijn, (Eds.), Reengineering the Chemical Process Plants, Process Intensification, Marcel Dekker, 2003.
12. Reay D., Ramshaw C., Harvey A., Process Intensification, Butterworth Heinemann, 2008.
13. Kamelia Boodhoo (Editor), Adam Harvey (Editor), Process Intensification Technologies for Green Chemistry: Engineering Solutions for Sustainable Chemical Processing, Wiley, 2013

Reference Books

1. Segovia-Hernández, Juan Gabriel, Bonilla-Petriciolet, Adrián (Eds.) Process Intensification in Chemical Engineering Design Optimization and Control, Springer, 2016.

Reay, Ramshaw, Harvey, Process Intensification, Engineering for Efficiency, Sustainability and Flexibility, Butterworth-Heinemann, 2013.	**Chemical Engineering Safety**	L	T	P	C
		3	0	0	3

Pre-requisites/Exposure	Knowledge of physics, chemistry, mathematics and transfer processes
Co-requisites	--

Course Objectives

1. Analyze the important technical fundamentals of chemical process safety.

2. Understand different types of fires and explosions and designs to prevent them.

3. Able to recognize and eliminate potential hazards by active or passive measures of design.

Course Outcomes

CO1. Define accident statistics and the need for safety in the chemical industry.

CO2. Understand the important technical fundamentals of chemical process safety.

CO3. Apply the fundamentals to solve problems occurring in the chemical industry.

CO4. Analyse source, toxic release and dispersion models as well as different types of fires and explosions.

CO5. Evaluate different scenarios pertaining to safety as occurring in the chemical industry.

Catalog Description

Complex processes, such as, at higher pressure, more reactive chemicals, and exotic chemistry. More complex processes require more complex safety technology. Many industrialists even believe that the development and application of safety technology is actually a constraint on the growth of the chemical industry. As chemical process technology becomes more complex, chemical engineers will need a more detailed and fundamental understanding of safety. H. H. Fawcett said, "To know is to survive and to ignore fundamentals is to court disaster." This book sets out the fundamentals of chemical process safety. Since 1950, significant technological advances have been made in chemical process safety. Today, safety is equal in importance to production and has developed into a scientific discipline that includes many highly technical and complex theories and practices.

Course Content
Unit I: 8 lecture hours
Introduction- Environmental Concern and Safety, Accidental statistical methods, significant industrial hazards of history,
Assignment-I ,
Unit II: 8 lecture hours
Fires and Explosions, Design to Prevent Fires and Explosions, Fire extinguishers, fire alarm systems,
Test-1,
Unit III: 10 lecture hours
Introduction Source Models, Laws and Regulations, Toxicology, Toxic Release and dispersion Models,
Assignment-2
Unit IV 10 lecture hours
Personnel Protective Equipment (PPE), Introduction to Reliefs and Relief Sizing,
Test-2,
Quiz-2,
Text Books
1. Chemical Process Safety: Fundamentals with Applications, Daniel A. Crowl and Joseph F. Louvar, Prentice Hall International, 1990 (T1).

Reference Books

1. Hydrocarbon Process Safety, J. C. Jones, Pennwell Books, 2003 (T2)

2. Loss Prevention in the Process Industries, F. P. Lees, 1980 (R1)

3. Emergency Response and Hazardous Chemical Management, Clyde B. Strong (R2)

4. S. Mannan and F. P. Lees, *Lees'Loss Prevention in the Process Industries*, Elsevier, Oxford, UK, 1980 (R3)
5. C. B. Strong, *Emergency Response and Hazardous Chemical Management: Principles and Practices*, CRC Press, Boca Raton, FL, 1996 (R4)

Web resources:

1. NPTEL video course on 'Chemical Process Safety' by Prof. Shishir Sinha of IIT Rourkee (link) https://www.digimat.in/nptel/courses/video/103107156/L01.html
2. Several videos on the accident process on USCSB's Youtube channel (link) https://www.youtube.com/user/USCSB/videos

Modes of Evaluation: Continuous mode (Quiz/Assignment/ presentation/ extempore/ Written Examination/viva)

Co-relationship matrix

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	3	-	-	-	-	-	-	-	-	3	3
CO2	3	3	3	3	-	-	-	-	-	-	-	-	3	3
CO3	3	3	3	3	-	-	-	-	-	-	-	-	3	3
CO4	3	3	3	3	-	-	-	-	-	-	-	-	3	3
CO5	3	3	3	3	-	-	-	-	-	-	-	-	3	3
Avg.	3	3	3	3	-	-	-	-	-	-	-	-	3	3

CHCE 4021P	**Chemical Industry 4.0**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**
Pre-requisites/Exposure	Basics of chemical Engineering				
Co-requisites					

Course Objectives:

1. To create awareness about the role of digitalization in chemical process industry.
2. To introduce the advanced production technologies for smart manufacturing.
3. To explain the biorefinery processes for fuels and chemicals production.
4. To provide the importance and development of sustainable polymers.

Course Outcomes:

CO1	Understanding the concept of digitalization in chemical process industry
CO2	Apply the digitalization technologies in advanced production processes
CO3	Analyze the separation techniques for biomass conversion products
CO4	Evaluate the routes of biodegradable polymer synthesis and biomass conversion to fuels and chemicals

Course Descriptions:

Chemical process industry is in the threshold of transition owing to shift in raw materials from non-renewables to renewables and pandemic situation necessitating digitalization. This course is aimed at introducing artificial intelligence, advanced production technologies and their deployment in chemical process industries. As renewables like biomass is the future of fuels and chemicals production, detailed description about biorefinery processes is to be delivered through this course. As non-biodegradable plastics based packaging materials has been recognized as source of pollution, this course will provide alternative biodegradable polymers for mitigation of pollution.

Course Curriculum:

Digitalization of Chemical Process Industry 8 h
Application of Artificial Intelligence (AI) in panel monitoring and instrumentation - Application of Internet of Things (IoT) in plant operation

Use of advanced production technologies - analytics, additive manufacturing, robotics, high performance computing, cognitive technologies, augmented reality (to enhance the value chain)- Advanced supply Chain Management Software for smart manufacturing. 10 h

Bio-refinery 12 h
Thermochemical conversions of biomass-Gasification, Pyrolysis, Fast pyrolysis, Hydropyrolysis, Hydrothermal liquefaction-Syngas to auto fuels and chemicals- FT synthesis, Methanol synthesis, Dimethyl ether, Methanol to Olefins (MTO), Methanol to Aromatics (MTA), platform molecules.
Biochemical conversions of biomass to biofuels-Bioethanol, bio-methane, bio-chemicals- platform molecules, health care products, cleaning agents, plasticizers.

Separation techniques for biomass and products in biomass conversion 10 h
Physical treatment – Mechanical treatment- Chemical treatments – Chromatography technique.

Sustainable Polymers 5 h
Biodegradable-Biocompatible polymers for packaging and medicinal applications.

Text Books:

1. Jean-Pierre Dal Pont and Marie Debacq, Process Industries 2: Digitalization, a New Key Driver for Industrial Management, 2020, Wiley.
2. K. Jayakrishna, K.E.K.Vimal, S. Aravind Raj, Asela K. Kulatunga, M.T.H. Sultan and J. Paulo Davim, Sustainable Manufacturing for Industry 4.0 An Augmented Approach, 2020, CRC Press.

3. Michele Aresta, Angela Dibenedetto and Franck Dumeignil, Biorefinery: From Biomass to Chemicals and Fuels, 2012, De Gruyter.
4. Vijay Kumar Thakur and Manju Kumari Thakur, Handbook of Sustainable Polymers Processing and Applications, 2016, Pan Stanford Publishing.

Reference Books:

1. Osvaldo A. Bascur, Digital Transformation for the Process Industries A Roadmap, 2020, CRC Press.
2. LaRoux K. Gillespie, Design for Advanced Manufacturing: Technologies and Processes**,** 2017, McGraw-Hill Education.
3. Jens Ejbye Schmidt, Juan-Rodrigo and Bastidas-Oyanedel, Biorefinery Integrated Sustainable Processes for Biomass Conversion to Biomaterials, Biofuels, and Fertilizers, 2019, Springer International Publishing.
4. Vimal Katiyar, Amit Kumar, Neha Mulchandani, Advances in Sustainable Polymers Synthesis, Fabrication and Characterization, 2020, Springer.

CO/PO Mapping for the course:

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3											3
CO2	3	3	3											3
CO3	3	3	3	3			3							3
CO4	3	3	3	3										3
Avg	3	3	3	3			3							3

CHCE 3051P	**Polymer Science, Processing and Applications**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**
Pre-requisites/Exposure	Chemistry, Reaction engineering				
Co-requisites					

Course Objectives:

1. To provide an understanding of the basic concepts of polymers, its processing and applications of polymers in allied industries.
2. To provide knowledge and understanding of polymer structures and reaction mechanisms.
3. To provide an understanding of various processing techniques used in the industry.

Course Outcomes:

CO1. Understand the basic concepts of polymers
CO2. Interpret the structure and properties of various polymers
CO3. Relate the structure, processing and application of polymers.

Course Descriptions:

This course provides an overview of polymer fundamentals, their synthesis, properties and their applications. It discusses the different polymerization methods such as step growth polymerization, radical chain polymerization, controlled radical polymerization. In this course the polymer processing techniques such as Injection molding, compression molding, extrusion, spinning, cold pressing, resin transfer molding will be discussed. This course will be helpful to anyone who is expiring to work on polymer industries and companies related to surface and interfacial technology like plastics, paints, rubber, resin, adhesives and advanced polymeric material industries.

Course Curriculum:

Unit 1: SCIENCE OF LARGE MOLECULES

a. Basic Concepts of Polymer Science
b. B The Rise of Macromolecular Science
c. Molecular Forces and Chemical Bonding in Polymers
d. Molecular Weight and Molecular-Weight Distribution

Unit 2: POLYMERIZATION

a. Condensation polymerization Classification of Polymers and Polymerization Mechanisms, Mechanism of Stepwise Polymerization.
b. Addition polymerization Mechanism of Vinyl Polymerization, Kinetics of Vinyl radical polymerization, Molecular Weight, and Its Distribution
c. Copolymerization Kinetics of' Copolymerization, Composition of' Copolymers, Mechanisms of Copolymerization

Unit 3: POLYMER PR0CESSING

a. Plastics Technology Molding, Extrusion, Other Processing Methods
b. Fiber Technology Textile and Fabric Properties, Spinning
c. Elastomer Technology Vulcanization, Reinforcement, Elastomer Properties and Compounding

Unit 4: POLYMER APPLICATIONS

Petrochemical, textile, chemical and allied industries, case studies.

Text Books:

1. Textbook of Polymer Science, 3rd Edition, Fred W. Billmeyer
2. Principles of polymerization, 4th edition, George Odian, Wiley
3. Introduction to polymers, 2nd edition, R. J. Young and P. A. Lovell, Nelson Thrones

Reference Books:

1. Polymers: Chemistry and Physics of Modern Materials, J. M. G. Cowie, CRC Press
2. The Physics of Polymers, Concepts for Understanding Their Structures and Behavior, Gert Strobl
3. ISBN 978-3-540-25278-8 Springer Berlin Heidelberg New York DOI 10.1007/978-3-540-68411-4

CO/PO Mapping for the course:

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3											2	2
CO2	3	3	3		3								3	3
CO3	3	3	3										2	2
CO4	3	3	3	3	3	2	2	2	2	2	2	3	3	3
Avg.	3	3	3	3	3	2	2	2	2	2	2	3	2.5	2.5

CHCE 3046P	**Specialty Chemicals**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**
Pre-requisites/Exposure	Chemical process industries				
Co-requisites					

Course Objectives:

1. To provide an understanding about adhesion and different types of adhesives.
2. To classify and describe the important agrochemicals, and their manufacturing.
3. To define, classify and describe the manufacture and industrial application of surfactants.
4. To give the role of different permitted food additives, their sources and synthesis.
5. To define the role of important lubricant additives and their synthesis.

Course Outcomes:

CO1 Understanding the different types of specialty Chemicals

CO2 Sketch the classification of various specialty chemicals

CO3 Analyze the synthesis routes of specialty chemicals

CO4 Critique the synthesis methods and application of specialty chemicals

CO5 Improve the performance of lubricants by formulating suitable additives.

Course Descriptions:

Speciality chemicals are low volume and high value compounds with special functions and characteristics. They are used in wide range of industries such as automotive, aerospace, food, cosmetics, agriculture, textiles etc. As components of equipment and instruments are made up of diverse materials, at times only way of assembling them together is by surface attachment using adhesives. To meet the food security, it is essential to protect the crops from insects, fungi, herbs and so on using agrochemicals. Lot of formulations and materials used in healthcare, oil & gas production, surface coatings use surfactants. As processed and semi processed food have become inevitable in today's life, several food additives are required to enhance and preserve them. Automobiles and several others involving moving parts are to be lubricated with formulated lubricants containing additives to meet the varied requirement. This course provides understanding about the compounds, functions and uses as adhesives, agrochemicals, surfactants, food additives and lubricant additives.

Course Curriculum:

Adhesives Definition –Theories of adhesion - Classification – Thermoplastic resin – Thermosetting resin – Elastomeric – Inorganic adhesives – Adhesives for special adherends – Anaerobic adhesives - Production and formulation.	7
Agrochemicals Insecticides – Manufacture, characteristics and use of Organochlorines, organophosphates, carbamates. Herbicides – classification – Manufacture of 2,4-D, Butachlor, Glyphosate, Atrazine and Benthiocarp. Fungicide – Classification – Manufacture of inorganic, organic and systemic fungicide.	9
Surfactants Definition –classification – synthesis - applications in emulsions, foams and solid dispersions – Industrial applications: food, oil & gas, pharmaceutical and surface coatings.	6
Food additives Colors: Permitted synthetic color additives – preservatives: Organic and inorganic – antioxidants: mechanism, synthetic antioxidants – flavors: aromatics and aliphatic compounds – antimicrobial: inorganic and organic.	9
Lubricant additives Viscosity index improvers – pour point depressants – antioxidants – corrosion inhibitors – extreme pressure additives – dispersant additives.	5

Text Books:

1. Sina Ebnesajjad, Adhesives Technology Handbook, Second Edition 2008, William Andrew.
2. H Panda, Agrochemicals, Pesticides, Insecticides, Fungicides, Herbicides, Biofertilizer, Vermicompost Manufacturing, 2003, National Institute of Industrial Research.
3. Drew Myers, Surfactant Science and Technology, Fourth edition 2020, Wiley.
4. A. Larry Branen, P. Michael Davidson, Seppo Salminen and John H. Thorngate III, Food Additives, Second edition 2001, Marcel Dekker.
5. Leslie R. Rudnick, Lubricant additives, Second edition 2009, CRC Press.

Reference Books:

1. Kashmiri L. Mittal, Handbook Of Adhesive Technology, Third edition 2017, CRC Press.
2. John H Montgomery, Agrochemicals Desk Reference, Second edition 1997, CRC Press.
3. Wasan, Surfactants in Chemical/Process Engineering, 1988, CRC Press.
4. Jim Smith and Lily Hong-Shum, Food Additives Data Book, 2011, Wiley
5. Edition by Leslie R. Rudnick, Lubricant Additives Chemistry And Applications, Third Edition 2017, CRC Press.

CO/PO Mapping for the course:

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2											2
CO2	3	2	2											2
CO3	3	2	2			2	2	2						2
CO4	3	2	2			2	2	2						2
CO5	3	2	2											2
Avg	3	2	2			2	2	2						2

CHCE 4028P	**Pharmaceutical Crystallization and Drug delivery**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**
Pre-requisites/Exposure	Mass, heat and momentum transfer, polymer chemistry				
Co-requisites					

Course Objectives:

1. Introduction to pharmaceutical crystallization, drug delivery systems and application of polymers
2. To disseminate the concepts of step cooling, crystallization, evaporative crystallization, liquid anti-solvent crystallization, and super critical fluid based crystallization the polymer synthesis process.
3. To explain the route specific delivery systems for drugs

Course Outcomes:

CO1. Understanding the basics of polymer classification, nomenclatures, and polymer reactions.
CO2. Sketch the reaction path of different polymer synthesis processes.
CO3. Analyse the effect of various parameters on polymer properties and synthesis method
CO4. Critique the polymer characteristics and their applications.

Course Descriptions:

This course provides an overview of pharmaceutical crystallization and drug delivery system. It discusses the concept of solubility, supersaturation, nucleation and growth to describe the crystallization phenomena. Different crystallization processes such liquid anti-solvent, super critical fluid based crystallization, evaporative crystallization are discussed. The commonly used polymers and biopolymers in drug-delivery and different drug-delivery systems such as dendrimers, liposomes, micelles, and hydrogels are also discussed. This course will be helpful to anyone who is expiring to work on pharmaceutical industries.

Course Curriculum:

Unit I: Introduction to crystallization and drug delivery – introduction, concept of solubility and super saturation, primary and secondary nucleation, size dependent and size independent growth, basic concepts of pharmacokinetics. — 7 Hours

Unit II: Pharmaceutical Crystallization process – Cooling crystallization, evaporative crystallization,, liquid anti-solvent crystallization, super critical fluid based crystallization — 12 Hours

Unit III: Polymers in drug delivery – Natural and synthetic, biocompatibility, Characterisation, crystallinity and amorphousness, biodegradation, commonly used polymers and biopolymers — 10 Hours

Unit IV: Drug delivery systems– Micro and nano particles: dendrimers, liposomes, micelles, hydrogels — 9 Hours

Unit V: Route specific delivery – Boral, subcutaneous, intramuscular, transdermal, inhalation, intravenous — 7 Hours

Text Books:

1. Crystallisation, 4th Edition By J. W. Mullin. 2001. Butterworth Heinemann
2. Drug Delivery: Fundamentals and Applications, Second Edition, Edited By Anya M Hillery, Kinam Park, CRC press. 2016

Reference Books:

1. Drug Delivery: Engineering Principles for Drug Therapy, W. Mark Saltzman, Oxford University press, 2001

CO/PO Mapping for the course:

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3											2	2
CO2	3	3	3		3								3	3
CO3	3	3	3										2	2
CO4	3	3	3	3	3	2	2	2	2	2	2	3	3	3
Avg.	3	3	3	3	3	2	2	2	2	2	2	3	2.5	2.5

CHCE 4029P	**Industrial safety and hazard management**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**
Pre-requisites/Exposure	Knowledge of physics, chemistry, mathematics and transfer processes				
Co-requisites					

Course Objectives:

1. Introduction of the important technical fundamentals of Industrial safety and hazard management
2. Understand different types of fires and explosions and designs to prevent them.
3. Able to recognize and eliminate potential hazards by active or passive measures of design.

Course Outcomes:

CO1. Understanding the requirement for safety in industry
CO2. Solve the toxicological and industrial hygiene problems using the concepts safety fundamentals
CO3. Analyse the various safety aspects of an industrial process.
CO4. Critique the safety approach in developing a good safety system

Course Descriptions:

A detailed and fundamental understanding of safety is very important for a chemical engineer since industry is becoming more complex and robust. Processes that are more complex require more complex safety technology. Today, safety is equally important to production and has developed into a scientific discipline. The course focuses on understanding the important technical fundamentals of industrial safety, hygiene, fire and explosions. The course will help the student to understand the safety concepts and practice them in actual scenario.

Course Curriculum:

Unit I: Introduction to Industrial safety - Introduction to Process Safety, Accident and loss statistics, Inherent safety, Few significant industrial disasters — 7 Hours

Unit II: Toxicology - Introduction to toxicology, Effect of toxicants on organisms, Toxicological studies, Dose vs. response curves, Threshold limit values — 12 Hours

Unit III: Industrial Hygiene - Introduction to industrial hygiene, Workplace monitoring, Estimating toxicant concentration in workplace, Industrial Control — 10 Hours

Unit IV: Source models– Introduction to source models, Flow of liquids through holes, Flow of liquids through pipes, Flow of gases through holes, Flow of gases through pipes – Adiabatic & Isothermal, Two-phase flow through holes, Liquid pool boiling — 9 Hours

Unit V: Fire and Explosions – The fire triangle, Flammability characteristics of liquid & vapor, limiting oxygen concentration & inerting, Flammability diagrams, Explosions, Concepts to prevent fires & explosions — 7 Hours

Text Books:

1. Chemical Process Safety: Fundamentals with Applications, Daniel A. Crowl and Joseph F. Louvar, Prentice Hall International, 1990 (T1).

Reference Books:

1. William Handley, Industrial Safety Hand Book McGraw-Hill Book Company 2nd Edition, 1977.
2. Fawatt, H.H. and Wood, W.S.Safety and Accident Prevention in Chemical Operation, Interscience, 1965.
3. Heinrich, H.W. Dan Peterson, P.E. and Nester Rood. Industrial Accident Prevention, McGraw-Hill Book Co., 1980
4. Blake, R.P., Industrial Safety, Prentice Hall Inc., New Jersy – 3rd Edn. 1963.
5. Ridley Safety at Work, VII Edition, Butterworth Heinman 2007

CO/PO Mapping for the course:

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3											2	2
CO2	3	3	3		3								3	3
CO3	3	3	3										2	2
CO4	3	3	3	3	3	2	2	2	2	2	2	3	3	3
Avg.	3	3	3	3	3	2	2	2	2	2	2	3	2.5	2.5

EPEG 3041P	Energy Management System	L	T	P	C
		3	0	0	3
Pre-requisites/Exposure	Basic knowledge of Energy/ Types of Energy and Renewable Energy				
Co-requisites	General Awareness of Energy and Environment				

Course Objectives:

1. Introduction to Energy scenario in India and globally along with the energy resources
2. Study types of energy and its impact on Environment
3. Understanding Energy conservation act in depth along with its Amendments
4. Understanding Energy Economy, Policies/Acts/Tariff related with Energy pricing etc.

Course Outcomes:

CO1. Understand various energy resources and reserves

CO2. Apply energy conservation techniques

CO3. Analyze critical issues in energy reforms

CO4. Evaluate various policies and strategies

Course Description:

This course is aimed to familiarize with the basic aspects of energy, its types and sustainable development at a greater depth. The subject provides an insight to the fundamentals of Energy along with Indian and Global Scenario. The most crucial part of this subject is the knowledge of steps taken at international level to prevent climate change one of which is the COP agenda.

Course Curriculum:

UNIT I: Energy utilization (8 hrs)

World energy use, reserves of energy resources, energy cycle of the earth, environmental aspects of energy utilization, renewable energy resources and their importance

UNIT II: Types and production of energy (10 hrs)

Types of energy: Primary & Secondary energy, commercial & non-commercial energy, non-renewable & renewable energy, primary energy resources, commercial energy production, energy conservation and its importance

UNIT III: Energy economy and security (9 hrs)

Energy Economy: Final energy consumption, Energy needs of growing economy, Long term energy scenario, Energy pricing, energy sector reforms, energy security, energy strategy for future

UNIT IV: Energy act and policy (10 hrs)

Energy conservation act, its features and related policies: features of the energy conservation act 2001 & the energy conservation (amendment) act, 2010, schemes under ect-2001, integrated energy policy, NAPCC

UNIT V: Energy management system (8 hrs)

Overview of International Energy management System ISO50001, clauses, implementation aspects, Benefits etc.

Text Books:

1. Introduction to Energy Analysis by Kornelis Blok, Techne Press, 2008, ISBN 9085940168.

2. Asian Energy Markets: Dynamics and Trends by I.B. Tauris, Emirates Center For Strategic Studies And Research, 02-March 2005, ISBN-13: 978-9948005698

3. Non-conventional Energy Sources by G.D .Rai (December 2004) ISBN-13: 978-8174090737

4. Energy Technology (Non-Conventional, Renewable & Conventional) by Sunil S Rao and B.B. Parulekar, Khanna Publishers; 3rd edition (2009) ISBN-13:978-8174090409

Reference Books:

1. ISO 50001 Energy Management Systems by Johannes Kals, 2015, Business Expert Press

CO/PO Mapping for the course:

PO/CO	PO 1	PO2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO11	PO 12	PSO 1	PSO 2
CO1	2	2		2										
CO2	2			3			2							2
CO3		3		3										
CO4		2						2						
Avg.														

EPEG 3040P	Renewable Energy Technologies	L	T	P	C
		3	0	0	3
Pre-requisites/Exposure	Applied science course				
Co-requisites	Mathematics				

Course objectives:

1. To identify various technologies utilizing renewable energy.
2. To understand the types of solar collectors and wind turbines
3. To enlist the applications of geothermal energy.
4. To analyse the parameters of conversion of biomass to energy
5. To design the equipment for hydrogen storage

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

1. Identify various technologies utilizing renewable energy.
2. Understand the types of solar collectors and wind turbines
3. Enlist the applications of geothermal energy.
4. Analyse the parameters of conversion of biomass to energy
5. Design the equipment for hydrogen storage

Course Description: The course covers various technologies of renewable energy. These are solar, wind, bioenergy, geothermal and hydrogen energy. Apart from the types of solar collectors and wind turbines, the technologies for conversion of biomass to energy have also been addressed. The generation of electricity from geothermal energy is a part of the course. Hydrogen production, storage, transportation and distribution have also been covered along with safety.

Unit 1: Solar energy technology (9hr)

Flat plate and Tubular Collectors. Solar Air Heaters: Types, Performance analysis. Thermal analysis. Sensible Storage, Latent Heat Storage, Thermo chemical storage. Solar cooker. Solar Operated Refrigeration Systems. Solar furnace.

Unit 2: Wind energy technology (9 hr)

Wind turbines, wind farms, small wind turbines and village power, performance and analysis.

Unit 3: Bioenergy technology (9 hr)

Introduction, conversion of biomass to bioenergy, landfill gas, biogas, biofuels

Unit 4: Geothermal energy technology (9 hr)

Types of Geothermal resources, direct use, springs, space heating and other, district heating, Geothermal heat pumps, generation of electricity.

Unit 5: Hydrogen energy technology (9 hr)

Introduction, properties and production of hydrogen, hydrogen storage methods, hydrogen transportation and distribution, hydrogen safety.

Text book:

1. Introduction to Renewable Energy, Energy and the Environment Series, Vaughn Nelson, CRC Press, Taylor & Francis Group, 2011.
2. Advances in Renewable Energies and Power Technologies: Volume 1: Solar and Wind Energies, Imene Yahvaoui, Elsevier, 2018.

Reference book:

1. Energy Efficiency and Renewable Energy Handbook, Editor D. Yogi Goswami and Frank Kreith, 2nd Edition, CRC Press, Taylor & Francis Group, 2016.

CO-PO Mapping

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	-	-	-	-	3	-	-	-	-	-	1	1
CO2	3	3	-	-	-	-	3	-	-	-	-	-	1	1
CO3	3	3	-	-	-	-	3	-	-	-	-	-	-	-
CO4	3	3	-	-	-	-	3	-	-	-	-	-	3	3
CO5	3	3					3						3	3
Avg	3	2	-	-	2	-	-	-	-	-	-	-	2	2

CIVL 4072P	Sustainability Engineering	L	T	P	C
		3	0	0	3
Pre-requisites/Exposure	Applied science course				
Co-requisites	Mathematics				

Course objectives:

1. To identify important factors related to sustainability
2. To analyze the variables responsible for power generation through solar, wind and hydrogen energy
3. To understand the potential of ocean, biomass and geothermal energy in the sustainable development.
4. To list the methods for recovery of CO_2 from process steams
5. To design the equipment for energy storage

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

1. Identify important factors related to sustainability
2. Analyse the variables responsible for power generation through solar, wind and hydrogen energy
3. Understand the potential of ocean, biomass and geothermal energy in the sustainable development.
4. List the methods for recovery of CO_2 from process steams
5. Design the equipment for energy storage

Course Description: The course covers various technologies for sustainable development. These are solar cells, village power, ocean energy, hydrogen energy, recovery of cold energy from LNG etc. The technologies for utilization of biomass for domestic cooking are also covered. conversion of biomass to energy have also been addressed. The generation of electricity from geothermal energy and hydrogen production, storage, transportation and distribution have also been covered along with safety aspects. Carbon neutrality through recovery of carbon dioxide is also one of the focussed areas of the course.

UNIT I : Solar and Wind Energy (9 hrs)

Solar Energy: Solar Radiation, Measurements of Solar Radiation, Solar Thermal Power Generation, Fundamentals of Solar Photo Voltaic Conversion, Solar Cells.

Wind Energy: Wind turbines, wind farms, village power, performance and analysis, estimation, site selection.

UNIT II: Ocean, Bio-mass and Geothermal Energy (9 hrs)

Ocean Energy: Ocean Thermal Energy Conversion (OTEC), Principle of operation, development of OTEC plants, Tidal and wave energy, Potential and conversion techniques

Bio-Mass: Principles of Bio-Conversion, Anaerobic/aerobic digestion, types of Bio-gas digesters, combustion characteristics of bio-gas, utilization for cooking.

Geothermal Energy: Resources, types of wells, methods of harnessing the energy, scope in India.

UNIT III: CO_2 recovery and carbon neutralities (9 hrs)

CO_2 recovery from process streams, net zero Emissions, low carbon, zero carbon, net zero energy building.

UNIT IV: Energy storage (9 hrs)

Introduction, technologies, pumped hydro, flywheels, batteries, cold energy storage, other storage systems.

UNIT V: Hydrogen energy (9 hrs)

Introduction, properties and production of hydrogen, hydrogen storage methods, hydrogen transportation and distribution, hydrogen safety.

Texts

1. Introduction to Renewable Energy, Energy and the Environment Series, Vaughn Nelson, CRC Press, Taylor & Francis Group, 2011.
2. Developments and innovation in carbon dioxide (CO2) capture and storage technology, vol 1, Editor M. Mercedes Maroto-Valer, CRC Press, Woodhead Publishing Limited, 2010.

References:

1. Energy Efficiency and Renewable Energy Handbook, Editor D. Yogi Goswami and Frank Kreith, 2nd Edition, CRC Press, Taylor & Francis Group, 2016.
2. Zhao, L., Dong, H., Tang, J., & Cai, J. (2016). Cold energy utilization of liquefied natural gas for capturing carbon dioxide in the flue gas from the magnesite processing industry. *Energy*, *105*, 45–56. https://doi.org/10.1016/j.energy.2015.08.110
3. He, T., Rong, Z., Zheng, J., Ju, Y., & Linga, P. (2019). LNG cold energy utilization : Prospects and challenges. *Energy*, *170*, 557–568. https://doi.org/10.1016/j.energy.2018.12.170

CO-PO Mapping

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	-	-	-	-	3	-	-	-	-	-	-	-
CO2	3	3	-	-	-	-	3	-	-	-	-	-	1	1
CO3	3	3	-	-	-	-	3	-	-	-	-	-	-	-
CO4	3	3	-	-	-	-	3	-	-	-	-	-	-	-
CO5	3	3	-	-	-	-	3	-	-	-	-	-	3	3
Avg	3	2	-	-	-	-	-	-	-	-	-	-	2	2

EPEG 4045P	Waste to Energy	L	T	P	C
		3	0	0	3
Pre-requisites/Exposure	Applied science course				
Co-requisites					

Course Objectives:

5. To enable students to understand the concept of waste to energy
6. To learn about the best available technologies for waste to energy
7. To facilitate the students in developing skills in the decision making process

Course Outcomes:

CO1. Analyse the various aspects of Waste to Energy Management Systems
CO2. Carry out Techno-economic feasibility of available technologies for Waste to Energy generation
CO3. Apply the knowledge in planning and operations of Waste to Energy plants

Course Description:

This course provides insights into the understanding of the various aspects of Waste to Energy. The need for characterization of wastes will be discussed along with the existing norms for waste utilization for the alternate energy source. This course emphasizes the various conversion routes available for energy generation along with the economics and feasibility.

Course Curriculum:

Unit 1: Introduction to Waste and its wealth potential (9 h)

Types of waste – Industrial, Commercial, Domestic and Agriculture waste. Nature of Waste – Solid, Liquid and Gaseous waste, Organic and Inorganic Analysis and Identification of Waste to wealth potential - Methods of analysis - Elemental and molecular composition – Thermal analysis – Chromatographic methods - Potential for waste to energy.

Unit 2 Preparation of the wastes for energy recovery (4 h)

Mechanical, physical, chemical and biochemical methods of treatment – Comparison and selection

Unit 3 Chemical processes for waste to energy (10 h)

Thermochemical conversions- Gasification, pyrolysis, hydro-pyrolysis, hydrothermal liquefaction, ih2, transesterification, hydrolysis, hydro-processing, syngas to energy products-Sabatier Process – Electrolytic methods & Fuel cells-Redox processes- Green Chemistry-Environmental benefits & concerns of Biomass Combustion technologies. Environmental benefits & concerns of Biomass Gasification, pyrolysis technologies.

Unit 4 Biochemical processes (7)

Biochemical pathways for waste to energy products– Biogas, P2G, 2G ethanol, biodiesel - Microbial growth kinetics of pure and mixed culture-Metabolic and media engineering-Microbial Fuel Cells-Electrochemical microbial cells, Environmental benefits & implications of biochemical conversion technologies

Unit 5 Regulatory Policies for Green Fuel Technologies (8)

Biomass Combustion technology: Central financial assistance for Biomass fired power generating & co-generation system. Available equipment purchase concessions. State Electricity Regulatory

Commission (SERC) initiatives (Preferential Tariffs & Renewable Purchase Standards (RPS)). Indian Renewable Energy Development Agency (IREDA) financial assistance schemes.

Unit 6: Biomass Gasification technology: (**7**)

Distributed / Off-grid power for Rural Areas. Captive power generation applications. Tail end grid connected power projects. Environmental, Economic and Policy Aspects of Biofuels. Economics and feasibility study of thermochemical and biochemical processes.

Text Books:

2. Waste Management: Research Advances to Convert Waste to Wealth by A.K HaGHI, Nova Science Publishers, Inc
3. Biomass to Energy Conversion Technologies: The Road to Commercialization by Pratima Bajpai, Elsevier Publisher.
4. Waste to Energy Conversion Technology by Naomi B Klinghoffer, Marco J Castaldi, Elsevier, 2013, ISBN: 0857096362, 9780857096364
5. Wealth from waste: Trends and Technologies by Banwari Lal and Priyangshu M Sharma, Publisher: The Energy and Resources Institute, TERI.

Reference Books:

1. Waste to Wealth, Springer, 2018, ISBN 978-981-10-7430-1 ISBN 978-981-10-7431-8

CO/PO Mapping for the course:

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO 8	PO 9	PO1 0	PO11	PO1 2	PSO 1	PSO 2
CO1	1	2	2	2			1							2
CO2	2	2		3		3	2						2	
CO3	3	3	2	2		2	2						3	2
Avg.														

CHCE 3021	Hydrogen Energy	L	T	P	C
		3	0	0	3
Pre-requisites/Exposure	Introduction to oil and gas				
Co-requisites	Applied sciences				

Course Objectives:

1 To outline the properties, sources and applications of hydrogen energy

2 To explain the process of hydrogen production from various materials

3 To identify the techniques for hydrogen separation

4 To analyze the major issues and challenges in hydrogen transport and storage

5 To understand hydrogen codes and standards

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

CO1 Outline the properties, sources and applications of hydrogen energy

CO2 Explain the process of hydrogen production from various materials

CO3 Identify the techniques for hydrogen separation

CO4 Analyze the major issues and challenges in hydrogen transport and storage

CO5 Understand hydrogen codes and standards

Course Description:

This course introduces hydrogen energy as future energy source. Production of hydrogen along with its separation, storage and transportation has been discussed. Production of hydrogen from fossil fuels as well as renewable materials, byproducts and waste materials also discussed. In addition, the role of membranes in hydrogen separation discussed. Finally, transport, storage along with safety and environmental aspects of hydrogen discussed.

Course Curriculum:

Unit-1 Introduction to hydrogen energy (8 hrs)

Hydrogen as a fuel. Properties of hydrogen. Sources of Hydrogen. Environmental Benefits. Hydrogen fuel cells. Other applications.

Unit-2 Hydrogen production (10 hrs)

Hydrogen production from coal. Methane steam reforming. Reforming of hydrocarbons and alcohols. Reformers. Catalysts. Hydrogen production from renewable raw materials, by-products, and waste.

Unit-3 Hydrogen separation (9 hrs)

Membranes for separation of hydrogen from different industrial streams. Properties of various membrane materials in respect of hydrogen. Separation of isotopes of hydrogen. Industrial membranes. Cryogenic distillation.

Unit-4 Hydrogen transport and storage (10 hrs)

Storage system capacity. Costs. Durability and operability requirements. Temperature, pressure, charging and discharging rates. Start-Up Time and Transient Response for Storage Systems. Hydrogen quality. Pipelines for Hydrogen Transport. Major issues in hydrogen transport through pipelines. Material challenges. Monitoring of pipelines. Hydrogen compression.

Unit 5 Safety and environmental aspects of hydrogen (8 hrs)

Hydrogen codes and standards. DOE Hydrogen Safety, Codes and Standards Program. National templates. Coordination of International and Domestic Codes and Standards.

Text Books:

1.Hydrogen Production, Separation and Purification for Energy. Editors Angelo Basile, Francesco Dalena, Jianhua Tong and T. Nejat Veziroglu. The Institution of Engineering and Technology, London, United Kingdom, 2017.

2.Hydrogen fuel-Production, Transport, and Storage. Editor Ram B. Gupta. CRC Press Taylor & Francis Group, 2009.

Reference Books:

1. Fuel Flexible Energy Generation: Solid, Liquid and Gaseous Fuels by John Oakey, Woodhead Publishing, ISBN: 978-1-78242-399-7 , 2016.
2. Handbook of Fuels: Energy Sources for Transportation by Introduction to Energy Analysis by Kornelis Blok, Techne Press, 2008, ISBN 9085940168.
3. Handbook of Alternative Fuel Technologies by Sunggyu Lee James G. Speight, CRC Press, Taylor & Francis Group, 2nd edition, 2015.
4. .Fuel cell fundamentals by Ryan O'HAYRE, and SUK-WON CHA, Wiley Publisher, 3rd edition (2016) ISBN- 978111911420

CO/PO Mapping for the course:

PO/CO	PO 1	PO2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO 12	PSO 1	PSO 2
CO1	3													
CO2	3	3											3	3
CO3	3	3												3
CO4	3	3												3
CO5						3	3							3
Avg.	3	3				3	3						3	3

SCHOOL OF LIFE

LIFE SKILLS

Sem.	Courses	Credits	Indicative Content	Method of Delivery
I	Learning How to Learn	2	Mental Tools to help you master new subjects. Brain-hacking and building lifelong habits	Exploratory assignments to unlearn. Workshops and interactive sessions, Online content Sports activities for team building Online tutorials Mock interviews, portfolio building, Industry Internship
II	Living Conversations	2	Reading, Deep Listening, Note Taking, Deep Conversation, Group Discussions, Presentation Skills. Essay Writing, Referencing, Interpersonal Communication, Public Speaking, Theatre	
III	Leadership and Teamwork	2	Leadership and communication skills, goal setting, time management techniques to collaborate more effectively in teams Also includes an exposure to. Diversity and Empathy	
IV	Design Thinking	2	Adopting a problem-solving approach and design thinking framework into all specializations	
V	Working with Data	2	Data and Analysis, Statistics, Spreadsheet	
VI	Persuasive Presence	2	Portfolio Building, interview skills, Social Media Presence, Signalling, Finding Mentors, Networking, Personal Branding, Presentations Skills etc.	

SIGNATURE COURSES

Sem.	Courses	Credits	Indicative Content	Method of Delivery
I	Critical Thinking and Writing	3	Introduction to Critical Thinking, Philosophy	Critical Thinking for the information Age & Quizzes. Robust Assessment Mechanism Strong linkages with institutions in Dehradun that are working on similar areas, ends in Himalaya Fellowship (Frugal Travel Internship) (Students bring back from their travel stories, objects,
I	Ethical Leadership in the 21th Century (Human Values and Ethics)	3	Ethical Challenges of the past such as Economic Development and Distribution of Wealth etc. Advances in Technology and new Ethical Challenges such as AI and Ethics, Data Privacy, Cyber laws and Ethics	
II	Start your Start up	3	From Idea to Market. Leadership, Strategy, Marketing, Project Management, Financial Literacy	
IV	Environment and Sustainability - Himalaya Fellowship	3	Systems of the Earth, Climate and Ecology, Nature, Anthropocene, Circularity, Sustainability, Cities and Villages, Indigenous practices and sustainability, Indian culture and sustainability.	

Sem.	Courses	Credits	Indicative Content	Method of Delivery
VI	Technologies of the Future	3	Could be a choice of technology from different specializations. Creative Computation, Broad Introduction of AI, ML, AR/VR, Quantum Computing, Coding for all capstone.	photos, recordings etc. to build an archive of the region at UPES Project Based with Online Lectures setting a context through industry applications. Workshops, Coaching, Lectures, Tie Up with TIFR for visiting lectures Introduction to Foresight & online sessions from UAL Online content plus workshop from Incubation Cell Invited lectures from Industry Project based approach & Mentoring
VI	Managing Relationships and Being Happy	3	Managing personal and professional relationships. Keeping in control of your life and happiness	
VI	Theory of Everything	3	String Theory, Relativity, Chaos theory etc.	
VI	Future Casting	3	Futuring, Building Insights based on broad trends, Speculation, Imagining future Scenarios, Future-hacking, Material Futures	
VII	Solving Complex Problems	3	Problem Solving, What is complexity?, Complex Systems, Cultural Complexity, Environment and Complexity	
VII	Digital Transformation	3	Technology and Business, Disruption, Trendspotting	
VII	Finding your Purpose in Life	3	Discovering who you are, what you love to do. Create a life purpose statement and a plan to achieve it.	
VII	India and its Place in the Contemporary World	3	Colonialism, Independence Movement, Nehruvian Modernity, Evolution of Democracy, Liberalization and Globalization, Demographic Dividend, Global Superpower, Indian Villages and Cities, Nationalism, Constitution	

EXPLORATORY COURSES

Courses	Credits	Courses	Credits
UI UX Design	3	Big Data Analytics	3
Photography Film and Video	3	AI for All	3
Financial Literacy	3	Marketing Management	3
Digital Marketing	3	Nutrition and Well Being	3
Project Management	3	Branding and Communication	3
Data Analytics and Visualization in Healthcare	3	How to lead a balanced and healthy life. Nutrition counselling, Fitness	3
MedTech: Digital Health and Wearable Technology	3	Basic laws and procedures	3
Responsible Citizenship and Law	3	Fashion Styling and Personal Grooming	3

SCHOOL OF LIFE COURSES - YEAR WISE PROGRESSION

Sem.	Code	Life Skills	Credits	Code	Signature Courses	Credits	Code	Exploratory Courses	Credits	Total
I	SLICL01	Learning how to learn	2							**2**
I	SLICL02	Living Conversations	2							**2**
II	SLICL03	Leadership and Teamwork	2	SLICS01	Critical Thinking and Writing	3				**5**
III	SLICL04	Design Thinking	2	SLICS02	Ethical Leadership in the 21st Century (Human Values and Ethics)	3	SLICE01	Exploratory Elective 1	3	**8**
IV	SLICL05	Working with Data	2	SLICS03	Environment and Sustainability - Himalaya Fellowship	3	SLICE02	Exploratory Elective 2	3	**8**
V	SLICL06	Persuasive Presence	2	SLICS04	Start your Start-up	3	SLICE03	Exploratory Elective 3	3	**8**
VI				SLIES01 SLIES02 SLIES03 SLIES04	*Choose from basket below:* Solving Complex Problems Technologies of the Future Future Casting Managing Relationships and Being Happy	3	SLICE04	Exploratory Elective 4	3	**6**
VII				SLIES05 SLIES06 SLIES07 SLIES08	*Choose from basket below* India and Its Place in the Contemporary World Theory of Everything Digital Transformation Finding your purpose in Life	3	SLICE05	Exploratory Elective 5	3	**6**
VIII							SLICE06	Exploratory Elective 6	3	**3**
Total Credits										**48**