UPES University

School of Advanced Engineering

B. Tech in Chemical Engineering

Programme Handbook

2023-2027

UPES Campus, "Energy Acres" & "Knowledge Acres"	Tel : + 91-135-2776053/54
Bidholi & Kandoli	Fax: + 91-135-2776090
Dehradun, Uttarakhand-248001	URL: www.upes.ac.in

Contents

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1.0 Abbreviations

Cat	-	Category
L	-	Lecture
T	-	Tutorial
P	-	Practical
Cr	-	Credits
ENGG	-	Engineering Sciences (including General, Core)
ELEC	-	Electives (University)
HUM	-	Humanities (including Languages, Social Sciences, and others)
SCI	-	Basic Sciences (including Mathematics)
PRJ	-	Project Work (including Seminars, Dissertation, and Internships)
PE	-	Program Elective (includes Specialization courses)
TC	-	Total Credits

APE	-	Applied Petroleum Engineering
AIE	-	Computer Science and Engineering-Artificial Intelligence
BIO	-	Biology
CCE	-	Computer Science and Communication Engineering
CHE	-	Chemical Engineering
CHY	-	Chemistry
CSE	-	Computer Science and Engineering
CVL	-	Civil Engineering
CUL	-	Cultural Education
EAC	-	Electronics and Computer Engineering
ECE	-	Electronics and Communication Engineering
EEE	-	Electrical and Electronics Engineering
ELC	-	Electrical and Computer Engineering
MAT	-	Mathematics

MEE	-	Mechanical Engineering
PHY	-	Physics
SoAE	-	School of Advanced Engineering
UE	-	University Elective (includes Signatory, Exploratory and Open Electives)

2.0 Vision and Mission of the University:

Vision of UPES

To be an Institution of Global standing for developing professionally competent talent contributing to nation building.

Mission of UPES

- Develop industry-focused professionals with an international outlook.
- Foster effective outcome-based education system to continually improve teaching-learning and research.
- Inculcate integrative thought process among students to instill lifelong learning.
- Create global knowledge eco-system through training, research & development, and consultancy.
- Practice and promote high standards of professional ethics and develop harmonious relationship with environment and society.

3.0 Vision and Mission of the School of Advanced Engineering

Vision of SoAE

To be a forerunner in engineering education by delivering excellent engineering graduates fortified with sound knowledge and integrity, by performing cutting-edge research and by innovating new technologies to benefit the nation and the world at large.

Mission of SoAE

- To develop industry focused engineers with expertise in the areas of oil and gas, energy, infrastructure, transportation, electronics, automotive design, and aviation.
- To sustain a strong focus on delivering excellent engineering and science education by providing an exposure to the concurrent research and industry trends and by employing innovative pedagogy tools/ techniques.

- To promote research, technology incubation and entrepreneurship to address the most pressing needs of our society and nation.
- To maintain a professional and ethical environment conducive to the intellectual growth of faculty and students, fostering communication, dialogue and sharing of ideas.
- To strengthen our linkages with academic institutes worldwide, industry and alumni network for evolving our programs towards better student outcomes.

4.0 About the Cluster/ Department/ Centre

The Energy Cluster envisages to instil the principles of engineering and then raise the bar to complex notions of technical application in the Energy Sector. Our curriculum includes seminars, projects, internships, and research-based learning. The Energy cluster offers three undergraduate and four postgraduate degrees. B. Tech Applied Petroleum Engineering was established in 2003 as a program dedicated to meet the industry requirements. M. Tech in Petroleum Engineering was established in 2007. B. Tech in Chemical Engineering and an M. Tech in Chemical Engineering started in the year 2009. B. Sc. Geology and M. Sc. Petroleum Geoscience programs started in 2020. M. Tech Renewable Energy was launched in 2023. All our undergraduate programs are NBA accredited. The research focus of this cluster is on clean energy, SDGs, unconventional hydrocarbon resources etc. Apart from this, the cluster is focused on providing holistic development of students. We ensure that the students are future-ready to meet the demands of the ever-changing industry needs. The curriculum is framed to include courses like Data Analytics, Digitization, Automation of process, AI/ML, etc., which will equip the students with additional skills which are going to be vital in the next 5 – 10 years.

Research Focus

The research focus of the cluster is aligned to the UN SDGs and national missions for energy and sustainability. Some of the focus areas are as below

Health & Sustainability

- HAP analysis and mitigation
- Cookstove design
- Drug formulation
- CO_2 sequestration

Geo - Hazards

- Paleoseismic Analysis
- Landslide studies
- Glacier Studies
- Neotectonics - GPR
- Oil spill

Clean Energy

- Geothermal Energy
- Fuel from mixed plastic
- HTL – catalyst development
- Algal biofuel
- Batteries

Unconventional HC resources

- Shale Gas exploration
- CBM exploration
- Gas Hydrates exploration & extraction

Water remediation

- Groundwater and surface water geochemistry
- Wastewater treatment

Petroleum E&P

- Reservoir characterization
- Basin analysis
- Petrophysics
- Seismic interpretations
- Drilling optimizations

5.0 Programme Overview

Chemical Engineers are the most versatile as they have a vital role in every aspect of process development and production of a large number of products such as chemicals, petrochemicals, pharmaceuticals, and consumer goods. The B. Tech Chemical Engineering program develops the fundamentals and advanced knowledge to operate, design, and develop the modern chemical processes and equipment. Our graduates learn fundamental courses such as Chemical Engineering Thermodynamics, Mass Transfer, Fluid Mechanics, Reaction Engineering, and Heat Transfer. These courses' robust laboratory helps students understand the theory courses conceptually. The exposure to advance courses such as Advanced Transport Phenomena, Carbon Capture Sequestration and Utilization, Advance Separation Process, and Circular Economy in Chemical Industries enable our students to develop new technology. These will help the students to develop green processes and to tackle emerging environmental concerns. The capstone project and programming courses will enable the graduates to adopt the interdisciplinary approach and solve the problems of the real world. The three specializations, Energy Systems and Storage, Digitalization of Process Technology, and Gas Engineering Informatics makes our graduates Engineers of Tomorrow. The research expertise of the department faculty provides the opportunity for fully funded Postgraduate and Ph.D. programs in the world's top universities. The major employers of our graduates are Exxon Mobil, Shell, Haliburton, Cairn Energy, Schlumberger, Reliance Industries Limited, and many more.

6.0 Programme Educational Objectives

PEO1 Graduates will develop a sound mathematical and scientific foundation, to provide Engineering solutions in Chemical and Energy areas.

PEO2 Graduates will have successful careers in leading Chemical and Energy industries.

PEO3 Graduates will interact with leading researchers and academicians of Chemical and Energy areas, to participate in lifelong learning and R&D

PEO4 Graduates will acquire lateral thinking and leadership skills to become industry leaders.

PEO5 Graduates will contribute to the welfare of the society /environment by taking professionally responsible decisions

7.0 Programme Outcome and Programme Specific Outcomes

Programme Outcomes

1. **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

7. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. Individual and 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 at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. **Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Programme Specific Outcomes

- **PSO 1-** Design and operate unit processes and equipment of modern chemical process and energy systems
- **PSO2:** Solve practical chemical engineering problems using heat and mass conservation and transfer, reaction kinetics, thermodynamics, process control, economics and safety.

8.0 Academic Integrity Policy

a. University Integrity Policy

b. Course integrity policy

9.0 Overview of Credit Allocation/ Credit Break up

Category-wise Credit distribution

Category	Number of Credits	Credit Percentage (%)
Basic Sciences - Core (SCI)	29	18%
Engineering Sciences - Core (ENGG)	69	42%
Programme Elective (PE)	15	9%
University Elective (UE)	18	11%
Humanities (HUM)	18	11%
Projects (PRJ)	16	10%
Mandatory Non-Credit Courses	0	0%
Total	**165**	

Electives

- Major core subjects include those subjects that are mandatory to all similar programmes and program specific courses. To be eligible for the degree, students must successfully finish each of the courses.
- Major elective courses provide the students the opportunity to study courses that are more complex and specialized, in their field of specialization.

Major Core	**Total number of Credits: 69 Credits**				
Course Code	**Course Title**	**L**	**T**	**P**	**TC**
CHCE2028	Chemical Technology	2	0	0	2
CHCE2029	Materials and Energy Balance Calculations	2	0	0	2
CSBA2013	Data Analytics and Machine Learning	3	0	0	3
CHCE2021	Process Heat Transfer	3	1	0	4
CHCE2003	Momentum Transfer	3	1	0	4
CHCE2002	Chemical Engineering Thermodynamics	3	1	0	4
CHCE2103	Momentum Transfer Lab	0	0	2	1
MECH2158	Heat Transfer Lab	0	0	2	1
CHCE2019	Numerical Methods in Chemical Engineering	3	1	0	4
CHCE2017	Mass Transfer	3	1	0	4
CHCE2030	Chemical Reaction Engineering	3	1	0	4
CHCE2111	Mass Transfer Lab	0	0	2	1
CHCE2130	Chemical Reaction Engineering Lab	0	0	2	1
CSEG1029	Programming	1	0	1	1

CHCE3050	Advanced Reaction Engineering	3	0	0	3
CHCE3053	Advanced separation process	3	0	0	3
CHCE3054	Energy sources	2	0	0	2
CHCE3057	Process Dynamics, Instrumentation & Control	3	1	0	4
CHCE3059	Process Economics	2	0	0	2
CHCE3058	Instrumentation and Control Lab	0	0	2	1
CHCE3062	Particulate Technology	2	0	0	3
CHCE3160	Particulate Technology Lab	0	0	2	1
CHCE4035	Carbon Technology and policies	3	0	0	3
CHCE4034	Advanced Transport Phenomena	3	0	0	3
				Total Credits	**69**
Humanities (HUM)	**Total Number of Credits: 18 Credits**				
Course Code	**Course Title**	**L**	**T**	**P**	**TC**
SLSG0102	Critical Thinking	2	0	0	2
SSEN0101	Environment, Sustainability, and Climate Change	2	0	0	2
SLLS0101	Living Conversations	2	0	0	2
SSEN0102	Environment, Sustainability, and Climate Change (Living Lab)	0	0	4	2
SLLS0201	Design Thinking	2	0	0	2
SLLS2001	Social Internship	0	0	0	0
SLLS0202	Working with Data	2	0	0	2
	Technologies of Future	2	0	0	2
SLLS0103	Leadership & Teamwork	2	0	0	2
SLSG0205	Start you own Start-up	2	0	0	2
				Total Credits	**18**
Projects (PRJ)	**Total Number of Credits: 16 Credits**				
Course Code	**Course Title**	**L**	**T**	**P**	**TC**
PROJ3149	Capstone I	0	0	4	2
PROJ3150	Capstone II	0	0	4	2
PROJ4101	Major Project I	0	0	8	4
PROJ4102	Major Project II	0	0	16	8
				Total Credits	**16**

Major Electives

Course Code	Course Title	L	T	P	TC
	Specialization Course I	3	0	0	3
	Specialization Course II	3	0	0	3
	Specialization Course III	3	0	0	3
	Specialization Course IV	3	0	0	3
	Specialization Course V	3	0	0	3

10.0Programme Structure

The term "Program Structure" refers to a list of courses (Core, Elective, and Open Elective) that make up an academic program, describing the syllabus, credits, hours of instruction, assessment and examination systems, minimum number of credits necessary for program graduation, etc.

Semester I:

Cat	Course Code	Course Title	L	T	P	TC	Prerequisites
HUM	SLSG0102	Critical Thinking	2	0	0	2	
HUM	SSEN0101	Environment, Sustainability, and Climate Change	2	0	0	2	
SCI	MATH1050	Engineering Mathematics I	3	1	0	4	11th and 12th Mathematics
SCI	PHYS1002	Physics	3	1	0	4	11th and 12th Physics
SCI	CSEG1008	Object Oriented Programming	3	0	0	3	
SCI	ECEG1004	Basic Electrical and Electronics Engg	3	0	0	3	11th and 12th Physics
SCI	CSEG1108	Object Oriented Programming Lab	0	0	2	1	
SCI	ECEG1104	Basic Electrical and Electronics Engg Lab	0	0	2	1	11th and 12th Physics
SCI	PHYS1102	Physics Lab	0	0	2	1	11th and 12th Physics
TC		**Total Credit**				**21**	

Semester II:

Cat	Course Code	Course Title	L	T	P	TC	Prerequisites
HUM	SLLS0101	Living Conversations	2	0	0	2	
HUM	SSEN0102	Environment, Sustainability, and Climate Change (Living Lab)	0	0	4	2	
ENGG	CHCE2028	Chemical Technology	2	0	0	2	Engineering Mathematics I, Physics, 12th Chemistry
SCI	MATH1051	Engineering Mathematics II	3	1	0	4	Engineering Mathematics I
SCI	MEPD1003	Workshop Practices	1	0	1	2	
SCI	MECH1001	Engineering Graphics	0	0	2	2	
SCI	CHCE1002	Process Chemistry	3	0	0	3	11th and 12th Chemistry
SCI	CHCE1101	Process chemistry Lab	0	0	2	1	11th and 12th Chemistry
ENGG	CHCE2029	Materials and Energy Balance Calculations	2	0	0	2	Engineering Mathematics I, Physics
TC		**Total Credit**				**20**	

Semester III:

Cat	Course Code	Course Title	L	T	P	TC	Prerequisites
UE		Exploratory 1	3	0	0	3	
HUM	SLLS0201	Design Thinking	2	0	0	2	
ENGG	CSBA2013	Data Analytics and Machine Learning	3	0	0	3	Engineering Mathematics I and II, Object oriented programming
ENGG	CHCE2021	Process Heat Transfer	3	1	0	4	Engineering Mathematics I and II
ENGG	CHCE2003	Momentum Transfer	3	1	0	4	Engineering Mathematics I and II, Physics

Cat	Course Code	Course Title	L	T	P	TC	Prerequisites
ENGG	CHCE2002	Chemical Engineering Thermodynamics	3	1	0	4	Engineering Mathematics I and II, Physics
HUM	SLLS2001	Social Internship	0	0	0	0	
ENGG	CHCE2103	Momentum Transfer Lab	0	0	2	1	
ENGG	MECH2158	Heat Transfer Lab	0	0	2	1	
TC		**Total Credit**				**22**	

Semester IV:

Cat	Course Code	Course Title	L	T	P	TC	Prerequisites
HUM	SLLS0202	Working with Data	2	0	0	2	
UE		Exploratory 2	3	0	0	3	
ENGG	CHCE2019	Numerical Methods in Chemical Engineering	3	1	0	4	Engineering Mathematics I and II
ENGG	CHCE2017	Mass Transfer	3	1	0	4	Material and Energy Balance computations, Chemical Engineering Thermodynamics
ENGG	CHCE2030	Chemical Reaction Engineering	3	1	0	4	Process Chemistry, Material and Energy Balance calculation
ENGG	CHCE2111	Mass Transfer Lab	0	0	2	1	
ENGG	CHCE2130	Chemical Reaction Engineering Lab	0	0	2	1	
ENGG	CSEG1029	Programming	1	0	1	1	Engineering Mathematics I and II, Object Oriented Programing
TC		**Total Credit**				**20**	

Semester V:

Cat	Course Code	Course Title	L	T	P	TC	Prerequisites
HUM	SLSG0103	Technologies of Future	2	0	0	2	
HUM	SLLS0103	Leadership & Teamwork	2	0	0	2	
UE		Exploratory 3	3	0	0	3	
PE		Specialization Course I	3	0	0	3	
ENGG	CHCE3050	Advanced Reaction Engineering	3	0	0	3	Chemical Reaction Engineering, Momentum transfer
ENGG	CHCE3053	Advanced separation process	3	0	0	3	Mass Transfer
ENGG	CHCE3054	Energy sources	2	0	0	2	
PRJ	PROJ3149	Capstone I	0	0	4	2	
TC		**Total Credit**				**20**	

Semester VI:

Cat	Course Code	Course Title	L	T	P	TC	Prerequisites
HUM	SLSG0205	Start you own Start-up	2	0	0	2	
UE		Exploratory 4	3	0	0	3	
PE		Specialization Course II	3	0	0	3	
ENGG	CHCE3057	Process Dynamics, Instrumentation & Control	3	1	0	4	Engineering Mathematics I and II, Physics
ENGG	CHCE3059	Process Economics	2	0	0	2	Process Heat Transfer, Mass Transfer
ENGG	CHCE3058	Instrumentation and Control Lab	0	0	2	1	
ENGG	CHCE3062	Particulate Technology	2	0	0	3	Momentum Transfer
ENGG	CHCE3160	Particulate Technology Lab	0	0	2	1	
PRJ	PROJ3150	Capstone II	0	0	4	2	Capstone I
PRJ	INDT3105	Industrial visit	0	0	0	0	
TC		**Total Credit**				**21**	

Semester VII:

Cat	Course Code	Course Title	L	T	P	TC	Prerequisites
UE		Exploratory 5	3	0	0	3	
PE		Specialization Course III	3	0	0	3	
PE		Specialization Course IV	3	0	0	3	
ENGG	CHGS4014	Process Design and Intensification	3	0	0	3	Momentum Transfer, Process Heat Transfer, Mass Transfer, Chemical Reaction Engineering
ENGG	CHCE4132	Design and Simulation lab	0	0	2	1	
ENGG	HSFS4033	Process Safety	3	0	0	3	
PRJ	PROJ4101	Major Project I	0	0	8	4	
PRJ	INDT4104	Industrial Internship	0	0	2	1	
TC		**Total Credit**				**21**	

Semester VIII:

Cat	Course Code	Course Title	L	T	P	TC	Prerequisites
UE		Exploratory 6	3	0	0	3	
PE		Specialization Course V	3	0	0	3	
ENGG	CHCE4035	Carbon Technology and policies	3	0	0	3	
ENGG	CHCE4034	Advanced Transport Phenomena	3	0	0	3	
PRJ	PROJ4102	Major Project II	0	0	16	8	Mass Transfer; Heat Transfer; Momentum Transfer
TC		**Total Credit**				**20**	

Specialization Tracks

The students enrolled in B. Tech. Applied Petroleum Engineering (4 year) would have an option to specialize in one the following emerging areas:

1. Energy Systems and Storage
2. Gas Engineering Informatics
3. Digitalization of Process Technology

The student must complete a minimum of 15 credits in the chosen area of specialization.

- If a student completes all courses from the same basket, then he/she will earn a specialization.
- If the student chooses the electives courses from different baskets, then he/she will not earn a specialization.
- Choice of specialization happens in the end of second year.

List of elective courses in specialization tracks

Major Elective 15 Credits						
Track 1 : Energy Systems and Storage						
Sem Offered	**Course Code**	**Course Title**	**L**	**T**	**P**	**TC**
V, VI	EPEG3040P	Renewable Energy Technologies	3	0	0	3
V, VI	EPEG3051P	Energy policies	3	0	0	3
VII, VIII	EPEG3052P	Energy storage systems	3	0	0	3
VII, VIII	EPEG4045P	Waste to Energy	3	0	0	3
VII, VIII	CHCE4027P	Hydrogen Energy	3	0	0	3
Track 2: Gas Engineering Informatics						
Sem Offered	**Course Code**	**Course Title**	**L**	**T**	**P**	**TC**
V, VI	CHGS3022P	Natural Gas Processing	3	0	0	3
V, VI	CHGS3007P	Pipeline Transportation of oil & Gas	3	0	0	3
VII, VIII	CHGS3033P	LNG & Storage of Natural Gas	3	0	0	3
VII, VIII	PEGS4018P	Applications of GIS	3	0	0	3
VII, VIII	CHCE4026P	Automation in Gas Industry	3	0	0	3
Track 3 : Digitalization of Process Technology						
Sem Offered	**Course Code**	**Course Title**	**L**	**T**	**P**	**TC**
V, VI	CHGS3132P	Process Modeling Simulation and Optimization*	3	0	0	3
V, VI	CHCE3055P	Chemical process data analytics	3	0	0	3
VII, VIII	CHCE3056P	Automation of Chemical processes	3	0	0	3
VII, VIII	CSIS4010P	Industrial Internet of Things	3	0	0	3
VII, VIII	CHCE4031P	Process Industry 4.0	3	0	0	3

Chemical Engineering Minor course requirement list

Students from other departments in the university have the option to take a minor degree from the Applied Petroleum Engineering stream. The list of course requirements to obtain a Applied Petroleum Engineering minor degree is as follows. Total credit for minor requirement is minimum twenty-four.

Mandatory Courses- 24 Credits*				
Sem Offered	**Course Code**	**Course Title**	**credits**	**Prerequisites**
III, V, VII		Introduction to Chemical Engineering	3	
III, V, VII	CHCE2002	Chemical Engineering Thermodynamics	3	Introduction to Chemical Engineering
III, V, VII	CHCE2003	Momentum Transfer	3	Introduction to Chemical Engineering
III, V, VII	CHCE2021	Process Heat Transfer	3	Introduction to Chemical Engineering
IV, VI, VIII	CHCE2017	Mass Transfer	3	Chemical Engineering Thermodynamics
IV, VI, VIII		Chemical Reaction Engineering	3	Mass Transfer

Energy Systems and Storage Minor course requirement list

Mandatory Courses- 24 Credits*				
Sem Offered	**Course Code**	**Course Title**	**credits**	**Prerequisites**
All sem	EPEG3051P	Energy policies	3	
All sem	EPEG3052P	Energy Storage Systems	3	
All sem	EPEG4045P	Waste to Energy	3	
All sem	CHCE4027P	Hydrogen Energy	3	
All sem	CHCE4035	Carbon Technology and policies	2	
IV, VI, VIII	PROJ3150	Capstone	0	

11.0 List of Electives

11.1 Programme Electives

11.1.1 Specializations

- Specializations are basket of electives of total 15 credits.
- If a student completes all courses from the same basket, then he/she will earn a specialization.
- If the student chooses the electives courses from different baskets, then he/she will not earn a specialization.
- Choice of specialization happens in the end of second year.

a) Specialization in Energy Systems and Storage

Sem Offered	Course Code	Course Title	L	T	P	TC
V, VI	EPEG3040P	Renewable Energy Technologies	3	0	0	3
V, VI	EPEG3051P	Energy policies	3	0	0	3
VII, VIII	EPEG3052P	Energy storage systems	3	0	0	3
VII, VIII	EPEG4045P	Waste to Energy	3	0	0	3
VII, VIII	CHCE4027P	Hydrogen Energy	3	0	0	3

b) Specialization in Gas Engineering Informatics

Sem Offered	Course Code	Course Title	L	T	P	TC
V, VI	CHGS3022P	Natural Gas Processing	3	0	0	3
V, VI	CHGS3007P	Pipeline Transportation of oil & Gas	3	0	0	3
VII, VIII	CHGS3033P	LNG & Storage of Natural Gas	3	0	0	3
VII, VIII	PEGS4018P	Applications of GIS	3	0	0	3
VII, VIII	CHCE4026P	Automation in Gas Industry	3	0	0	3

c) Specialization in Digitalization of Process Technology

Sem Offered	Course Code	Course Title	L	T	P	TC
V, VI	CHGS3132P	Process Modeling Simulation and Optimization*	3	0	0	3

Sem Offered	Course Code	Course Title	L	T	P	TC
V, VI	CHCE3055P	Chemical process data analytics	3	0	0	3
VII, VIII	CHCE4026P	Automation of Chemical processes	3	0	0	3
VII, VIII	CSIS4010P	Industrial Internet of Things	3	0	0	3
VII, VIII	CHCE4031P	Process Industry 4.0	3	0	0	3

11.2 University Electives

11.2.1 Signature Courses

11.2.2 Exploratory Courses

11.2.3 Open Elective

12.0Course Syllabus/ Course Plans

SEMESTER I

MATH1050	Engineering Mathematics I	L	T	P	C
		3	1	0	4
Pre-requisites/Exposure	Basic Mathematics (10+2 level)				
Co-requisites					

Course Objectives:

1. Provide both theoretical as well as practical use of differential and integral calculus.
2. Employ vector analysis and vector calculus for modelling physical and engineering problems.
3. Develop capability and skill set to model situations governed by linear and nonlinear differential equations.

Course Outcomes:

CO1	Understand the power of calculus for gaining insight into problems of interest.
CO2	Explore the concept of vector-valued functions as applied in engineering applications.
CO3	Formulate and analyze mathematical models of a variety of real-world problems.
CO4	Develop and visualize solutions of nonlinear mathematical models.

Course Descriptions:

This course introduces essential mathematics and its applications for addressing complex real-life engineering, social, and biological problems. It illustrates the comprehensive usage of integral and differential calculus with their applications in modeling. Vector calculus and its innovative usage in higher dimensions are made accessible with examples and visual presentations. Besides understanding these basic concepts, the course provides insights into the dynamic behavior of real-life situations formulated through linear and nonlinear differential equations. Further, illustrative examples dealing with Logistic equation, Lotka-Volterra predator-prey model, and Nonlinear oscillators, would be investigated. Employing GeoGebra tools/MATLAB would provide rich dynamic behaviors of systems of interest.

Course Curriculum:

Unit 0: Motivation **1 Hour**

Why study this course? Application of Calculus and Differential equations in addressing real-world problems.

Unit I: Differential Calculus **9 Hours**

Review: Functions and their graphs, polynomial, exponential, and logarithmic functions, Remainder and Factor theorems of polynomials.

Limits, Continuity and Differentiability, Rolle's theorem, Lagrange's and Cauchy mean value theorems, Successive differentiation, Leibnitz's theorem, Taylor's series without proof, Lagrange's form of remainder, Functions of several variables, Partial differentiation, Euler's theorem, Jacobian, Maxima and minima. Recap of Unit-I.

Unit II: Integral Calculus **9 Hours**

Definite integrals and properties, Double integrals: Cartesian and Polar co-ordinates, Cylindrical and Spherical coordinates, change of order of integration, Change of variables, Triple integrals, Gamma, Beta functions and their properties, Applications of Calculus: Real-world problems. Recap of Unit-II.

Unit III: Vector Algebra and Calculus- **9 Hours**

Motivation, Vector algebra, Scalar and vector point functions, Vector Differentiation, Gradient, Divergence and Curl, Vector Integration: Line integral, Surface integral, Volume integral, Application of integrals: Work, Circulation and Flux, Green, Gauss, and Stokes theorems (without proof) and their applications. Recap of Unit-III.

Unit IV: Linear Differential Equations with Visualizations – **11 Hours**

Motivation: Linearity vs non-linearity, Linear superposition principle, First-order linear differential equations: Exact differential equations. Integrating Factors. Applications of first-order linear equations: Electric circuits, Radioactive decay, Population growth. Second and Higher order linear differential equations: Solution of homogeneous and non-homogeneous equations with constant coefficients, Wronskian, Solution of second-order differential equation by variation of parameters, Autonomous vs non-autonomous systems, Applications: Harmonic oscillator, Electric Circuits. Visualization Tool: GeoGebra https://www.geogebra.org/t/differential-equation. Recap of Unit-IV.

Unit V: Non-Linear Differential Equations with Visualizations: **6 Hours**

Brief history of interdisciplinary studies of nonlinear systems, Pendulum equations, Phase portraits, Linearization around equilibrium, Nonlinear models: Logistic equation, Bass model of diffusion of innovation, Lotka-Volterra predator-prey model, Epidemic models-SIR, Application to the nerve impulse. Visualization Tool: GeoGebra https://www.geogebra.org/t/differential-equation. Recap of Unit V.

Text Books:

1. Thomas, G. B. and Finney, R. L., Calculus and Analytical Geometry, Pearson Education India, ISBN: 9788174906168, 2010.
2. James, G. and Dyke, P. P., Advanced Modern Engineering Mathematics. Pearson Education. ISBN: 9781292174341, 2018.
3. Kreyszig E., Advanced Engineering Mathematics, Wiley Publications. ISBN: 9780471488859, 2005.

SS Reference Books:

1. Apostol T. M., Mathematical Analysis, Narosa. ISBN: 9788185015668, 2002.
2. Braun M., Differential Equations and their Applications, Springer, ISBN: 9780387943305, 1994.
3. Strogatz S. H., Nonlinear Dynamics and Chaos, CRC Press, ISBN: 9781138329454, 2014.
4. Enns R. H., It's a Nonlinear World, Springer, ISBN: 978-0387753386,

Web Resources and Supplementary Materials:

1. Strogatz, S. Love Affairs and Differential Equations. 1988. https://userpages.umbc.edu/~rostamia/math481/love-dynamics/love-dynamics-1988.pdf

2. https://blogs.cornell.edu/info2040/2018/11/29/sir-model-epidemics-and-social-media/
3. https://www.jstor.org/stable/1252012.
4. Visualization Tool: GeoGebra https://www.geogebra.org/t/differential-equation.
5. Givon, M., Mahajan, V. and Muller, E.. Software piracy: Estimation of lost sales and the impact on software diffusion. Journal of Marketing, 59(1), 29-37,1995 https://www.jstor.org/stable/1252012.
6. Singh, A., Basic Calculus. https://archive.nptel.ac.in/courses/111/106/111106146/
7. MIT OCW on Differential Equations. https://ocw.mit.edu/courses/18-03-differential-equations-spring-2010/video_galleries/video-Hours/

Suggested Scope for Future Enquiry

Students may like to explore

i) Maxwell's equations in electrodynamics,
ii) Formulation of differential equations for Double pendulum.

CO/PO Mapping for the course:

PO/CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2
CO1	3	3	2	1	1	-	-	-	-	-	-	1	-	
CO2	3	3	2	1	1	-	-	-	-	-	-	1	-	-
CO3	3	3	2	1	1	-	-	-	-	-	-	1	-	-
CO4	3	3	2	1	1	-	-	-	-	-	-	1	-	-
Avg	3	3	2	1	1	-	-	-	-	-	-	1	-	-

1=Weakly mapped 2= Moderately mapped 3=Strongly mapped

PHYS1002	**Physics**	**L**	**T**	**P**	**C**
		3	**1**	**0**	**4**
Pre-requisites/Exposure					
Co-requisites					

Course Objectives:

1. Underst and 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	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	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 I: 20 Hours

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.

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 II: **20 Hours**

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.

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

Unit III: **20 Hours**

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.

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	1	-
CO2	3	-	-	-	-	-	-	-	-	-	-	1	1	-
CO3	3	3	-	-	-	-	-	-	-	-	-	1	1	-
Avg	3	2	-	-	-	-	-	-	-	-	-	1	1	-

CSEG1008	Object Oriented Programming	L	T	P	C
		3	0	0	3
Pre-requisites/Exposure					
Co-requisites					

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 Hours 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 I: **7 Hours**

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.

Unit II: **8 Hours**

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

Unit III: **7 Hours**

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

Unit IV: **6 Hours**

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.

Unit V **8Hours**

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.

Textbooks:

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	-	-	2
Avg	3	2	2	-	1	-	-	-	-	-	1	-	-	2

1=Weakly mapped 2= Moderately mapped 3=Strongly mapped

ECEG1004	Basic Electrical and Electronics Engineering	L	T	P	C
		3	0	0	3
Pre-requisites/Exposure	11th and 12th Physics				
Co-requisites					

Course Objectives

1. To enable students understand the fundamental semiconductor devices.
2. To enable students understands the logical operations and network theory.
3. To enable students acquire knowledge about electrical machine and transformer.

Course Outcomes

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

CO 1	Employ electronic and electrical components and devices to solve the Engineering problems.
CO 2	Analyze and make simple circuits and Systems of Electrical and Electronics Engineering, Interpret the logics used in the Circuits and Systems.
CO 3	Design the electrical system with discrete components and to understand the specifications of industrial equipments.
CO4	Design the electronics system with discrete components and to understand the specifications of industrial equipment.

CO-PO Mapping

PO /CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO 1	2	2	2	1	-	-	-	-	-	-	-	1	2	2	-
CO 2	2	2	2	1	1	-	-	-	-	-	-	1	1	2	-
CO 3	3	3	2	-	1	-	-	-	-	-	-	1	1	2	-
CO 4	3	3	2	-	1	-	-	-	-	-	-	1	2	2	-
Average	2.5	2.5	2	0.5	1	-	-	-	-	-	-	1	1.5	2	1

1 – Weakly Mapped (Low) **2 – Moderately Mapped (Medium)**

3 – Strongly Mapped (High) **"_" means there is no correlation**

Syllabus

Unit I- Semiconductor Devices **16 Lecture Hours**

Diode: Fundamental Characteristics of diode: Formation of P-N junction, I-V characteristics, half-wave and full-wave rectifier circuits, Zener and Avalanche breakdown; diode applications in clipper and clamper, Zener diode: voltage regulator.

Transistor: Construction and operation, Transistor amplifying action, Amplification factors; Limits of operation, Applications of transistor, DC-Biasing: Fixed bias, Emitter bias, Voltage divider bias.

Unit II- Boolean Algebra **7 Lecture Hours**

Number system and codes, Minimization techniques: Boolean logic operations, Basic laws of Boolean algebra, De Morgan's Theorems; Logic gates: AND, OR, NAND, NOR and realization. Implementation of Adder and subtractor, Two, three and four variables Karnaugh-map (K-map)

Unit III- Network Theory **10 Lecture Hours**

Voltage and current sources (conversion), Kirchoff current and voltage laws, Network theorems (DC/AC): Superposition, Thevenin's and Maximum Power Transfer theorem, star-delta transformations.

Unit IV - AC Circuits and Electrical Machines **12 Lecture Hours**

Representation of sinusoidal waveforms, peak and RMS values, phasor representation. Elementary analysis of single-phase ac circuits R, L, C, series/parallel RLC circuits and Resonance conditions. DC machines: working Principle transformer, losses in transformers & efficiency; Classification of motors (AC & DC), characteristics & applications of DC Motors

Textbooks

1. Principle of Electronics by V.K. Mehta & Rohit Mehta 2018, S. Chand
2. Basic Electrical Engineering, V.K. Mehta, 2018, S. Chand.
3. Digital Circuits & Logic Design by Salivahanan: Vikas Publishing House.
4. Basic Electronics by Santiram Kal, 2013: PHI.

Reference Books

1. 1NPTEL Lectures –will be available - \\10.2.1.33 (intranet)

Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination

Examination Scheme:

Components	IA	MID SEM	End Sem	Total
Weightage (%)	50	20	30	100

CSEG1108	Object Oriented Programming Lab	L	T	P	C
		0	0	2	1
Pre-requisites/Exposure	11th and 12th science				
Co-requisites					

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	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	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	-	-	-	-	-	-	-	-

ECEG1104	Basic Electrical and Electronics Engineering Lab	L	T	P	C
		0	0	2	1
Pre-requisites/Exposure	11th and 12th Physics				
Co-requisites					

Course Objectives

1. Understand the characteristics of the basic electronic components like diode and transistor and electric fuse.
2. Develop the application-based circuits using switch, Rectifier, Diode and transistor and logic gates also.
3. Design DC-Power supply by using Rectifiers and Adders & Subtractor by using Logic Gates.
4. Apply laws to solve the DC & AC network Circuits using R, L, C circuits.
5. Study the Constructional features, operation and characteristics of Electrical Machines.

Course Outcomes

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

CO 1 Understand the functionality of electronics and electrical components.

CO 2 Analyze and interpret the data obtained during experiments of Electrical and Electronics circuits.

CO 3 Evaluate the results of the experiments based on different fundamental theorems/laws.

CO-PO Mapping

Program Outcomes / Course Outcomes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2
CO 1	-	-	2	2	-	-	-	-	-	-	-	-	2	1
CO 2	-	-	2	2	-	-	-	-	-	-	-	-	2	1
CO 3	-	-	2	2	-	-	-	-	-	-	-	-	2	1
CO4	-	-	2	2	-	-	-	-	-	-	-	-	2	1
Average	-	-	2	2	-	-	-	-	-	-	-	-	2	1

1 – Weakly Mapped (Low) **2 – Moderately Mapped (Medium)**

3 – Strongly Mapped (High) **"_" means there is no correlation**

Experiments list

S. No.	Experiment
Exp-1	To study various electronic components (diode, resistor, transistor, capacitors, ICs, etc) and measuring instruments.
Exp-2	To study the voltage and current measurement using volt-meter and ammeter connections in simple electrical circuit.

Exp-3	To plot V-I characteristics of PN junction diode.
Exp-4	To verify Thevenin’s Theorem.
Exp-5	To study half-wave and full-wave rectifier circuit.
Exp-6	To verify Superposition Theorem
Exp-7	To study the characteristics of NPN transistor in CE configuration.
Exp-8	To verify the Maximum Power Transfer Theorem
Exp-9	To study the characteristics of NPN transistor in CB configuration.
Exp-10	To study the phenomenon of resonance in L-C-R series circuit
Exp-11	Implementation of Half and Full Adder digital circuits.
Exp-12	To study the phenomenon of resonance in LCR parallel circuits.

Textbooks

1. Principle of Electronics by V.K. Mehta & Rohit Mehta 2018, S. Chand
2. Basic Electronics By Santiram Kal, 2013: PHI.

Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination
Examination Scheme:

Components	**Continuous Evaluation**
Weightage (%)	100

PHYS1102	Physics Lab	L	T	P	C
		0	0	2	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	PSO3
CO1	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-
CO2	-	3	-	-	-	-	-	-	-	-	-	-	1	-	-
CO3	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-
CO4	-	-	3	-	2	-	-	-	-	-	-	-	-	-	-
Avg	-	3	3	3	2	-	-	-	-	-	-	-	1	-	-

PHYS1102	Physics Lab	L	T	P	C
		0	0	2	1
Pre-requisites/Exposure	12^{th} physics				
Co-requisites					

Course Objectives:

5. To impart hand-on skills in performing experiments, data acquisition and interpretation of the data.
6. To design the circuits and study about various experimental procedures involved.
7. Significance of the experimental results to understand and verify theoretical formulation and prediction.
8. 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:

11. To study the Hall effect and hence determine the Hall coefficient (R_h) and carrier density (n) of a given semiconductor material.
12. To study the induced emf as a function of velocity of the magnet passing through the coil (Faraday's Law).
13. To study the charge delivered due to electromagnetic induction.
14. 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.
15. To study the characteristics of photocurrent vs voltage at different frequency.
16. To determine the wavelength of a given light by forming Newton's Rings.
17. To determine the wavelength of a given light by using a Diffraction grating in its normal incidence position.
18. To determine the Numerical Aperture of an optical fibre and study about the bending losses.
19. To find the Planck's constant by using LEDs.
20. Presentation related to any science concept.

Text Books:

4. H. Singh, Practical Physics, S. Chand & Company LTD., ISBN: 8121904692.
5. S. L. Kakani, S. Kakani, Applied Physics-Theory & Practicals, Viva Books, ISBN: 9788130924892.
6. 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	PSO3
CO1	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-
CO2	-	3	-	-	-	-	-	-	-	-	-	-	1	-	-
CO3	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-
CO4	-	-	3	-	2	-	-	-	-	-	-	-	-	-	-
Avg	-	3	3	3	2	-	-	-	-	-	-	-	1	-	-

SLSG0102	Critical Thinking and Writing	L	T	P	C
Version 1.0	-	2	0	0	2
Pre-requisites/Exposure	-				
Co-requisites	-				

Course Objectives

The objectives of this course are:

- To introduce the essential tools and approaches of critical thinking.
- To realize how several factors hinders the process of critical thinking and how to overcome them.
- To understand and the various components and conventions of critical writing and create appropriate documents.

Course Outcomes

CO 1	Understand the importance of Critical Thinking in the process of decision making.
CO 2	Differentiate amongst the various tools and approaches of critical thinking; look at the world around objectively and critically
CO 3	Critically analyze any text and communicate the inferences drawn after analysis; introspect and reflect on their thought processes; draw logical conclusions and identify the errors in reasoning
CO 4	Articulate written documents demonstrating critical approaches with clear, structured and quality writing.
CO 5	Apply critical thinking to any provided information. Identify, understand and define the various arguments in different contexts

Catalog Description

The ability to think clearly and rationally is important in whatever we choose to do. **Critical thinking is the ability to think clearly and rationally about what to do or what to believe a**nd includes the ability to engage in reflective and independent thinking. Critical Thinking and Writing skills are important to help one progress in their professional and personal life effectively. This course aims to introduce the various tools and methods available to develop critical thinking. It will equip students to utilize critical thinking concepts and strategies in learning, and apply those skills for effective written communication, thus developing the ability to think critically and communicate effectively.

Course Content

Unit-1 **2hours**
Food for Thought:
What is Critical Thinking?
Introduction to the course, its importance and its application in life. Focus is given on the Trolly problem and how it can never be solved.

Unit-2 **2 hours**

Learning how to learn:
Cognition and Metacognition
The highlight of this unit would be learning strategies and the development of Bloom's Taxonomy. This leacture based class will focus on education and learning challenges faced by students across South Asia and how to over come them.

Unit-3 **2 hours**
How to not judge a book by its cover:
Cognitive biases
Flagging the problems with assumptions in our everyday functioning, this class will highlight the various kinds of biases and how it effects our understanding of issues when it comes to problem solving.

Unit-4
Writing to read **8 hours**
Introduction to various aspects of writing and highlighting how one is different from the other. Understanding of capital letters and syntaxes will be another focus of these classes.

Unit-5 **2 hours**
"…but why?":
The Social, The Historical, and the Political Aspects of Reasoning:
Introduction to inductive and deductive reasoning and its relevance when understanding how information is passed on to.

Unit- 6 **4 hours**
"Agree to disagree":
Explanation, Justification, Persuasion
Explanation, Justification, Persuasion are three distinct critical thinking tool to convey information, support arguments, or influence others in various contexts.

Unit 7 **2 hours**
Fact, Truth, and Misinformation
Based in accuracy and reliability of information, this unite with focus on assertion of statement that can be objectively verified and proven to be true or false depending upon the situation. It is important to be critically evaluate information to differentiate one from the other.

Unit 8 **2 hours**
Critical Consumption
Focusing on critical media consumption, this unit focuses on the contemporary forms of information consumption. It involves being actively aware if potential biases, misinformation, and the credibility of sources in the age of digital media.

Unit 9 **2 hours**
POV:
Perspective Taking
This unit focuses on the Cognitive and empathetic process in which an individual tries to understand and empathise with the thoughts, feelings, beliefs, and experiences of the other person or group from their point of view. Perspective taking is an important aspect of empathy and interpersonal communication aiding critical thinking

Unit 10: **2 hours**
Ethical Dilemma
The focus of this unit will be on the complex moral decision that involves conflicting values, principles, or interests. In such instances there is no clear or obvious choice to arrive at a conclusion.

Text Books

1. Vaughn, Lewis (2005). The Power of Critical Thinking: Effective Reasoning About Ordinary and Extraordinary Claims. New York: Oxford University Press USA.
2. Hughes, William (2015). Critical thinking: an introduction to the basic skills. Tonawanda, NY: Broadview Press. Edited by Katheryn Doran & Jonathan Allen Lavery.
3. West, Andrew (2014). Ubuntu and Business Ethics: Problems, Perspectives and Prospects. Journal of Business Ethics 121 (1):47-61.

Reference Books

1. Yu, Shiyang & Zenker, Frank (2020). Schemes, Critical Questions, and Complete Argument Evaluation. Argumentation 34 (4):469-498.
2. Davies, Richard (2020). In Defence of a Fallacy. Studia Semiotyczne 34 (2):25-42.
3. Lumer, Christoph (2019). Recognizing Argument Types and Adding Missing Reasons. In Bart J. Garssen, David Godden, Gordon Mitchell & Jean Wagemans (eds.), Proceedings of the Ninth Conference of the International Society for the Study of Argumentation (ISSA). [Amsterdam, July 3-6, 2018.]. Amsterdam (Netherlands): pp. 769-777.

Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination

Examination Scheme:

Components	Class writing assignment and participation	Quiz 1	Quiz 2	Writing assignment
Weightage (%)	10	30	30	30

B.Tech CSE 2023 Program Outcomes

PO1	Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2	Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3	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.
PO4	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.
PO5	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.
PO6	The engineer and society: Apply reasoning informed by contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to professional engineering practice.
PO7	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.
PO8	Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice.
PO9	Individual and teamwork: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10	Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO11	Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO12	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.

Relationship between the Course Outcomes (COs), Program Outcomes (POs) and Program Specific Objectives (PSOs)

Program Outcomes Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO 1	-	1	-	1	1	1	1	-	3	3	1	1
CO 2	-	2	1	-	2	1	1	-	2	3	1	1
CO 3	-	1	1	-	2	-	1	1	1	3	1	1
CO 4	-	-	1	-	2	1	1	1	2	3	-	1
CO 5	**-**	**2**	**-**	**2**	**3**	**-**	**-**	**1**	**3**	**1**	**-**	**3**

Average	**-**	**1.5**	**1**	**1.5**	**2**	**1**	**1**	**1**	**2.2**	**2.6**	**1**	**1.4**

1=weak 2= moderate 3=strong

SSEN0101	Course Name	L	T	P	C
SSEN0101	Environment Sustainability and Climate Change	2	0	0	2
Pre-requisites/Exposure	Fundamentals of basic ecology, chemistry and physics				
Co-requisites					

Course Objectives (CO) :

I. To Develop a critical understanding of the nature, cause and impact of human activities on the environment.
II. Critically engage with concepts of ecosystems, biodiversity and sustainability.
III. Research, analyse, identify problems, develop insights, and frame sustainable solutions to living issues faced by the global and local communities.
IV. Learning by doing, engaging, exploring and experimenting

Course Outcomes

CO-1:Understand the concepts of ecology, sustainability, climate change and environment related to everyday life.
CO-2: Distinguish and relate different types of biodiversity and natural resources and their impact on sustainable development.
CO-3: Analyse various aspects of environment and adopt eco-friendly technologies to facilitate conservation and regeneration of natural resource.
CO-4: Build environmental awareness through a wide range of curricular and co-curricular activities at the University and later in a professional/vocational practice.

Catalog Description:

This course aims at sensitizing students to the environment and the balance of natural and manmade ecosystems. Develop empathy and concern for the environment and evolve as conscious participants in resolving issues affecting local and global environment. The course seeks to build an interdisciplinary approach and analytical skills, with an element of creativity towards achieving a sustainable future. Under this programme we shall be provide indepth knowledge in various area such as climate change, pollution, waste management, sanitation, conservation of biological diversity, management of biological resources and biodiversity, forest and wildlife conservation, and sustainable development.

Course Content

Unit 1 Humans and the Environment **4 lecture hours**

The man-environment interaction: Humans as hunter-gatherers; Mastery of fire; Origin of agriculture; Emergence of city-states; Great ancient civilizations and the environment; Middle Ages and Renaissance; Industrial revolution and its impact on the environment; Population growth and natural resource exploitation; Global environmental change.

The emergence of environmentalism: Anthropocentric and eco-centric perspectives (Major thinkers); The Club of Rome- Limits to Growth; UN Conference on Human Environment 1972; World Commission on Environment and Development and the concept of sustainable development; Rio Summit and subsequent international efforts.

Unit 2 Natural Resources and Sustainable Development **6 lecture hours**

Overview of natural resources: Definition of resource; Classification of natural resources- biotic and abiotic, renewable and non-renewable.

Biotic resources: Major type of biotic resources- forests, grasslands, wetlands, wildlife and aquatic (fresh water and marine); Microbes as a resource; Status and challenges.

Water resources: Types of water resources- fresh water and marine resources; Availability and use of water resources; Environmental impact of over-exploitation, issues and challenges; Water scarcity and stress; Conflicts over water.

Soil and mineral resources: Important minerals; Mineral exploitation; Environmental problems due to extraction of minerals and use; Soil as a resource and its degradation.

Energy resources: Sources of energy and their classification, renewable and non-renewable sources of energy; Conventional energy sources- coal, oil, natural gas, nuclear energy; Non-conventional energy sources- solar, wind, tidal, hydro, wave, ocean thermal, geothermal, biomass, hydrogen and fuel cells; Implications of energy use on the environment.

Introduction to sustainable development: Sustainable Development Goals (SDGs)- targets and indicators, challenges and strategies for SDGs.

Unit 3 Environmental Issues: Local, Regional and Global **6 lecture hours**

Environmental issues and scales: Concepts of micro-, meso-, synoptic and planetary scales; Temporal and spatial extents of local, regional, and global phenomena.

Pollution: Impact of sectoral processes on Environment, Types of Pollution- air, noise, water, soil, municipal solid waste, hazardous waste; Transboundary air pollution; Acid rain; Smog.

Land use and Land cover change: land degradation, deforestation, desertification, urbanization.

Biodiversity loss: past and current trends, impact.

Global change: Ozone layer depletion; Climate change.

Unit 4 Conservation of Biodiversity and Ecosystem **6 lecture hours**

Biodiversity and its distribution: Biodiversity as a natural resource; Levels and types of biodiversity; Biodiversity in India and the world; Biodiversity hotspots; Species and ecosystem threat categories.

Ecosystems and ecosystem services: Major ecosystem types in India and their basic characteristics- forests, wetlands, grasslands, agriculture, coastal and marine; Ecosystem services- classification and their significance.

Threats to biodiversity and ecosystems: Land use and land cover change; Commercial exploitation of species; Invasive species; Fire, disasters and climate change.

Major conservation policies: in-situ and ex-situ conservation approaches; Major protected areas; National and International Instruments for biodiversity conservation; the role of traditional knowledge, community-based conservation; Gender and conservation.

Unit 5 Environment Pollution and Health **6 lecture Hours**

Understanding pollution: Production processes and generation of wastes; Assimilative capacity of the environment; Definition of pollution; Point sources and non-point sources of pollution.

Air pollution: Sources of air pollution; Primary and secondary pollutants; Criteria pollutants- carbon monoxide, lead, nitrogen oxides, ground-level ozone, particulate matter and sulphur dioxide; Other important air pollutants- Volatile Organic compounds (VOCs), Peroxyacetyl Nitrate (PAN), Polycyclic aromatic hydrocarbons (PAHs) and Persistent organic pollutants (POPs); Indoor air pollution; Adverse health impacts of air pollutants; National Ambient Air Quality Standards.

Water pollution: Sources of water pollution; River, lake and marine pollution, groundwater pollution; water quality Water quality parameters and standards; adverse health impacts of water pollution on human and aquatic life.

Soil pollution and solid waste: Soil pollutants and their sources; Solid and hazardous waste; Impact on human health.

Noise pollution: Definition of noise; Unit of measurement of noise pollution; Sources of noise pollution; Noise standards; adverse impacts of noise on human health.

Thermal and Radioactive pollution: Sources and impact on human health and ecosystems.

Unit 6 Climate Change Impact Adaptation and Mitigation 6 lecture Hours

climate change from greenhouse gas emissions– past, present and future; Projections of global climate change with special reference to temperature, rainfall, climate variability and extreme events; Importance of 1.5 °C and 2.0 °C limits to global warming; Climate change projections for the Indian sub-continent.

Impacts, vulnerability and adaptation to climate change: Observed impacts of climate change on ocean and land systems; Sea level rise, changes in marine and coastal ecosystems; Impacts on forests and natural ecosystems; Impacts on animal species, agriculture, health, urban infrastructure; the concept of vulnerability and its assessment; Adaptation vs. resilience; Climate-resilient development; Indigenous knowledge for adaptation to climate change.

Mitigation of climate change: Synergies between adaptation and mitigation measures; Green House Gas (GHG) reduction vs. sink enhancement; Concept of carbon intensity, energy intensity and carbon neutrality; National and international policy instruments for mitigation, decarbonizing pathways and net zero targets for the future; Energy efficiency measures; Renewable energy sources; Carbon capture and storage, National climate action plan and *Intended Nationally Determined Contributions* (INDCs); Climate justice.

Unit 7 Environment Management 6 Lecture Hours

Introduction to environmental laws and regulation: Constitutional provisions- Article 48A, Article 51A (g) and other derived environmental rights; Introduction to environmental legislations on the forest, wildlife and pollution control.

Environmental management system: ISO 14001

Life cycle analysis; Cost-benefit analysis

Environmental audit and impact assessment; Environmental risk assessment

Pollution control and management; Waste Management- Concept of 3R (Reduce, Recycle and Reuse) and sustainability; Ecolabeling /Ecomark scheme

Unit 8 Environment Treaties and Legislation 6 Lecture Hours

1. An overview of instruments of international cooperation; bilateral and multilateral agreements; conventions and protocols; adoption, signature, ratification and entry into force; binding and non-binding measures; Conference of the Parties (COP)

2. Major International Environmental Agreements: Convention on Biological Diversity (CBD); Cartagena Protocol on Biosafety; Nagoya Protocol on Access and Benefit-sharing; Convention on International Trade in Endangered Species of 6ild Flora and Fauna (CITES); Ramsar Convention on Wetlands of International Importance; United Nations Convention to Combat Desertification (UNCCD); Vienna Convention for the Protection of the Ozone Layer; Montreal Protocol on Substances that Deplete the Ozone Layer and the Kigali Amendment; Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal; Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous

Chemicals and Pesticides in International Trade; Stockholm Convention on Persistent Organic Pollutants; Minamata Convention on Mercury; United Nations Framework Convention on Climate Change (UNFCCC); Kyoto Protocol; Paris Agreement; India's status as a party to major conventions

3. Major Indian Environmental Legislations: The Wild Life (Protection) Act, 1972; The Water (Prevention and Control of Pollution) Act, 1974; The Forest (Conservation) Act, 1980; The Air (Prevention and Control of Pollution) Act, 1981; The Environment (Protection) Act, 1986; The Biological Diversity Act, 2002; The Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006; Noise Pollution (Regulation and Control) Rules, 2000; Industry-specific environmental standards; Waste management rules; Ramsar sites; Biosphere reserves; Protected Areas; Ecologically Sensitive Areas; Coastal Regulation Zone; Status phase-out of production and consumption of Ozone Depleting Substances by India; National Green Tribunal; Some landmark Supreme Court judgements

Major International organisations and initiatives: United Nations Environment Programme (UNEP), International Union for Conservation of Nature (IUCN),World Commission on Environment and Development (WCED), United Nations Educational, Scientific and Cultural Organization (UNESCO), Intergovernmental Panel on Climate Change (IPCC), and Man and the Biosphere (MAB) programme.

Unit 10 Living Lab Case Studies and Field Work 30 hours

The students are expected to be engaged in some of the following or similar identified activities:

- Discussion on one national and one international case study related to the environment and sustainable development.
- Field visits to identify local/regional environmental issues, make observations including data collection and prepare a brief report.
- Documentation of campus biodiversity.
- Campus environmental management activities such as solid waste disposal, water management, and sewage treatment

Reference Books

1. Fisher, Michael H. (2018) An Environmental History of India- From Earliest Times to the Twenty-First Century, Cambridge University Press.

1. Headrick, Daniel R. (2020) Humans versus Nature- A Global Environmental History, Oxford University Press.

2. William P.Cunningham and Mary A. (2015) Cunningham Environmental Science: A Global Concern, Publisher (Mc-Graw Hill, USA)

4. Gilbert M. Masters and W. P. (2008). An Introduction to Environmental Engineering and Science, Ela Publisher (Pearson)

3. Rajagopalan, R. (2011). Environmental Studies: From Crisis to Cure. India: Oxford University Press.**University Grants Commission 11.**

4. William P. Cunningham and Mary A. (2015). Cunningham Environmental Science: A global concern, Publisher (Mc-Graw Hill, USA)

5. Bhagwat, Shonil (Editor) (2018) Conservation and Development in India: Reimagining Wilderness, Earthscan Conservation and Development, Routledge.

6. Masters, G. M., & Ela, W. P. (2008). *Introduction to environmental engineering and science* (No. 60457). Englewood Cliffs, NJ: Prentice Hall.

7. Miller, G. T., & Spoolman, S. (2015) Environmental Science. Cengage Learning.

8. Central Pollution Control Board Web page for various pollution standards. https://cpcb.nic.in/standards/

9. Ahluwalia, V. K. (2015). *Environmental Pollution, and Health*. The Energy and Resources Institute (TERI).**University Grants Commission 13**

10. Denle A., Azadi H., Arbiol J. (2015). Global assessment of technological innovation for climate change adaptation and mitigation in developing world, Journal of Environmental Management, 161 (15): 261-275.

11. Richard A. Marcantonio, Marc Lame (2022). Environmental Management: Concepts and Practical Skills. Cambridge University Press.**University Grants Commission 15**

12. UNEP (2007) Multilateral Environmental Agreement Negotiator's Handbook, University of Joensuu, ISBN 978-952-458-992-5

13. Ministry of Environment, Forest and Climate Change (2019) A Handbook on International Environment Conventions & Programmes. https://moef.gov.in/wp- content/uploads/2020/02/convention-V-16-CURVE-web.pdf

Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination

Components	Internal Assessment	Mid-Semester Examination (MSE)	ESE
Weightage (%)	30	20	50

Correlation between the Course Outcomes (COs) and Program Outcomes (POs) Table :

PO/CO	**PO**	**PO**	**PO**	**PO**	**PO**	**PO**	**PO**	**PO**	**PO**	**PO**	**PO**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
CO1	2										
CO2	2	1			1						
CO3	3	1		1	2			1			2
CO4	2	2		1	1			1			1
Average	2.25	1.3		1	1.3			1			1.5

1=Weakly mapped 2= Moderately mapped 3=Strongly mapped

SEMESTER II

MATH1051	Engineering Mathematics II	L	T	P	C
		3	1	0	4
Pre-requisites/Exposure	Engineering Mathematics I				
Co-requisites					

Course Objectives:

The course aims to prepare the students to understand and appreciate the power of mathematics as a unifying language transcending a variety of engineering and science disciplines. The focus for the designing of the syllabus has been to provide the students with insights into the mathematical concepts and their applications without much compromising mathematical rigor.

Course Outcomes:

CO1	Formulate appropriate numerical and optimization schemes for the development of computational algorithms in science and engineering.
CO2	Understand the fundamental tools of complex analysis for addressing and solving a variety of problems viz. special functions, integral transforms, and PDEs
CO3	Identify and illustrate the use of Bessel functions and Legendre polynomials in real world application.
CO4	Demonstrate computational implementation of integral transforms and their applications.
CO5	Model real-world phenomena evolving in space and time governed by linear PDEs

Course Descriptions:

A good grounding in mathematical sciences has become necessary for the emerging areas like AI/ML, Big data analytics, Underwater image processing, Quantum computing, Cybersecurity, Computational biology, etc. Engineering Mathematics II is intended to improve students' computational and analytical abilities, enabling them to model and create algorithms for a range of real-world problems. To this end, several topics are covered, including numerical methods, optimization, complex analysis, integral transforms, special functions, and linear PDEs. It will be beneficial for students to have knowledge of gradient search algorithms as machine learning and many other areas involve some kind of gradient search in optimization. Further, it may be emphasized that complex analysis is useful in several branches of science and engineering such as probability theory, number theory, thermodynamics, signal processing, and image processing. Realizing the importance of partial differential equations and their visualization across many disciplines, a brief introduction to linear PDEs have become prerequisites to gaining insight into the evolutionary dynamics of realistic problems.

Course Curriculum:

Unit 0: Motivation: Why study this course- Relevance and Significance? **1 Hour**

Unit 1: Numerical Methods and Optimization- Bisection and Newton-Raphson methods, Gauss Elimination and Gauss-Seidel methods, Finite difference operators, Interpolation with equal and unequal intervals, Numerical differentiation, and integration, Numerical solution of ODEs: Picard's method, Euler's method, Runge-Kutta fourth order method. **13 Hours**

Introduction to optimization, The Simplex method, Duality, Lagrange multipliers, Convex sets and functions, Elements of Gradient search algorithms: Steepest descent, Newton and Jacobi algorithms, Least Squares method, Application: The Markowitz Model, and Overview of constrained optimization, Hill climbing, Single variable search. Recap of Unit I.

Unit 2: Infinite Series and Introduction to Complex Analysis - Sequence and series, Convergence tests: p-series, Comparison, Ratio and root test, Alternating series. **13 Hours**

Complex number system, Euler's formula, Functions of a complex variable, Hyperbolic functions, Limit and Continuity, Derivative and Analytic functions, Holomorphic functions, Cauchy-Riemann equations, Harmonic functions, Line integral and independence of path, Cauchy's theorem, Cauchy's integral formula, Zeros and singularities of a function, Power series: Taylor's and Laurent's series. Some applications. Recap of Unit II.

Unit 3: Introduction to Special Functions - Introduction to Power series method, Legendre's equation and Legendre polynomials, Bessel's equation and Bessel functions. Application of Bessel functions: CV Raman's model of Indian drums. Recap of Unit III **4 Hours**

Unit 4: Integral Transforms - Laplace Transform and its properties, Shifting Theorems, Laplace Transform of derivatives, integrals, and periodic functions, Heaviside and Dirac Delta Functions. Inverse Laplace transforms, Convolution, Solutions of differential equations using Laplace transforms. Fourier series and applications, Dirichlet's condition, Fourier Transforms, Fourier sine and cosine transforms, Properties of Fourier Transforms, Fast Fourier Transform, Inverse Fourier transforms. Recap of Unit IV **8 Hours**

Unit 5: Introduction to PDEs and Applications- Introduction to Partial differential equations (PDE) and real-world applications, Classification of PDEs: Elliptic, Hyperbolic, Parabolic, Solution of homogeneous and non-homogeneous linear PDEs, Method of separation of variables using Fourier series, Solution of Heat conduction or Diffusion equation, Connection between diffusion and randomness, Wave Equation, Laplace Equation, and Poisson Equation. Some applications: Air pollution, Traffic model. Recap of Unit V. 08 Hours

Textbooks*:*

1. Kreyszig E., Advanced Engineering Mathematics, Wiley Publications. ISBN: 9780471488859, 2005.
2. James, G. and Dyke, P. P., Advanced Modern Engineering Mathematics. Pearson Education. ISBN: 9781292174341, 2018.
3. Corriou, J. P., Numerical Methods and Optimization: Theory and Practice for Engineers. Springer. ISBN: 9783030893651, 2021.

Reference Books:

1. Zill, D.G. and Shanahan, P.D., Complex analysis. Jones & Bartlett Learning. ISBN: 9789384323127, 2015.
2. Strauss, W.A., Partial Differential Equations - An Introduction. John Wiley & Sons Inc. ISBN: 9780470054567, 2008.
3. Burstein, L. PDE Toolbox Primer for Engineering Applications with MATLAB® Basics. CRC Press, 2022.

4. Goodfellow, I., Bengio, Y., and Courville, A. Deep learning. MIT Press. ISBN: 9780262035613, 2016. (Sections 4.3, 4.4, and 4.5)
5. Chandra, S., Jayadeva, and Mehra, A., Numerical optimization with applications. Narosa. ISBN: 9788173198540, 2009.

Web Resources and Supplementary Materials:

1. Gaudet, S., Gauthier, C., & Léger, S. (2006). The evolution of harmonic Indian musical drums: A mathematical perspective. Journal of sound and vibration, 291(1-2), 388-394.
2. MIT OCW on Complex Variables with Applications. https://ocw.mit.edu/courses/18-04-complex-variables-with-applications-spring-2018/
3. Balakrishnan, V., Selected Topics in Mathematical Physics https://nptel.ac.in/courses/115106086.
4. Hsu T.R., Applied Engineering Analysis, John Wiley & Sons. ISBN: 9781119071181, 2017.
5. Neunzert H., Industrial Mathematics and India: A View from the Outside, TMCB, https://www.themathconsortium.in/publication/timcbulletin/vol2/issue1

Future Scope of Enquiry:

Students may like to explore nonlinear PDE:

i) Reaction-Diffusion equations see Murray J.D., Mathematical Biology: I & II, Springer.
ii) Dissipation and displacement of hotspots in reaction-diffusion models of crime, PNAS, 2010. https://www.pnas.org/doi/epdf/10.1073/pnas.0910921107

CO/PO Mapping for the course:

PO/CO	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO10**	**PO11**	**PO12**	**PSO 1**	**PSO 2**
CO1	3	2	-	-	1	-	-	-	-	1	-	-	-	2
CO2	3	2	-	-	1	-	-	-	-	1	-	-	-	2
CO3	3	2	-	-	1	-	-	-	-	1	-	-	-	-
CO4	3	2	-	-	1	-	-	-	-	1	-	-	-	2
CO5	3	2	-	-	1	-	-	-	-	1	-	-	-	2
Avg	3	2	-	-	1	-	-	-	-	1	-	-	-	2

1=Weakly mapped 2= Moderately mapped 3=Strongly mapped

MEPD1003	**Workshop Practices**	L	T	P	C
		1	0	2	2
Pre-requisites/Exposure	Workshop practice theory course				
Co-requisites					

Course Objectives

1. To impart knowledge and skill of components in the field of basic workshop practices.
2. To deal with different hand and machine tools required for manufacturing simple components.
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.
5. To impart knowledge of dimensional tolerances with different manufacturing processes.

Course Outcomes:

CO1: Understand the basics of manufacturing processes used in engineering workshop.
CO2: Identify basic workshop hand and machine tools.
CO3: Fabricate simple models by using different Manufacturing processes.

CO4: Compare conventional and advanced manufacturing processes.

Catalog Description

Workshop technology is the backbone of the real industrial environment that 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 knowledge 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 as domestic life helps to solve the problems. The workshop experiences would help to build an 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 content:

UNIT 1 **4 LECTURE HOURS**

Manufacturing Methods, Forming process –hot working and cold working processes – types. Machining Advanced manufacturing processes- introduction to non-conventional machining processes and their needs.

UNIT 2 **2 LECTURE HOURS**

Fitting operations & power tools, limits, fits and tolerance. Types of power tools.

UNIT 3 **2 LECTURE HOURS**

Metal casting patterns-types, allowances, molding sand-its properties, types of molds and cores, melting equipment.

UNIT 4 **3 LECTURE HOURS**

Welding (arc welding & gas welding), brazing, Gas welding.

UNIT 5 **1 LECTURE HOURS**

Carpentry Types of woods, defects of wood, seasoning of wood, types of carpentry tools. Additive manufacturing –additive v/s subtractive manufacturing, need, advantages and applications of additive manufacturing, introduction to 3 D printing.

List of Experiments:

Experiment No: 01

Prepare lab layout of the workshop with layout of all shops: carpentry, fitting, machine, welding, smithy, sheet metal and foundry shop.

Experiment No: 02
To fabricate a T-lap joint of given dimensions using common carpentry tools.
Experiment No: 03
To fabricate a cross lap joint of given dimensions using common carpentry tools.
Experiment No: 04
To develop a square fitting model of given dimensions by using fitting tools.
Experiment No: 05
To learn lathe operation and develop a step turning model of given dimensions by using lathe machine.
Experiment No: 06
To develop a model of given dimension by using facing, turning, grooving, parting and knurling operations.
Experiment No: 07
To learn welding operation and develop a T- joint, V-butt joint and Lap joint using electric arc welding process.
Experiment No: 08
To develop a rectangular tray in sheet metal shop using various hand tools for working with sheet metal
Experiment No: 09
To develop a chisel using common smithy hand tools.
Experiment No: 10
To develop a cope and drag mould in foundry shop.
Textbooks / Reference Books

1. Work shop Manual / P.Kannaiah/ K.L.Narayana/ SciTech Publishers.
2. Engineering Practices Lab Manual, Jeyapoovan, Saravana Pandian, Vikas publishers
3. Dictionary of Mechanical Engineering, GHF Nayler, Jaico Publishing House.

Modes of Evaluation: Class tests/Assignment/Tutorial Assessment/Written Examination

Examination Scheme:

Components	Quizzes/Tests, Assignments	Lab Evaluation	ESE
Weightage (%)	35	35	30

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

PO/ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO 1	1	-	1	-	-	-	1	-	-	-	-	-
CO 2	1	-	1	-	-	-	-	-	-	-	-	-
CO 3	-	-	-	-	3	-	-	-	2	-	-	2
CO 4	1	-	-	-	2	-	-	-	-	-	-	-
Average	1	-	1	-	2.5	-	1	-	2	-	-	2

1 = weakly mapped 2 = moderately mapped 3 = strongly mapped

MECH1001	Engineering Graphics	L	T	P	C
		1	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.

Course Outcomes:
At the end of this course student should be able to
CO1: Remember the conventions of engineering graphics such as types of lines, dimensioning, method of projection etc.
CO2: Demonstrate understanding of fundamental concepts of engineering graphics.
CO3: Apply knowledge of orthographic and isometric projections to solve problems related to points, lines, planes, and solids.
CO4: Develop and model basic engineering components.

Catalog Description:
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 Content

UNIT -1: Fundamental of engineering graphics and projections: 2 lectures
Principles of Engineering Graphics and their significance, usage of Drawing instruments; Sheet layout, sketching, Lines, Lettering and Dimensioning rules;
UNIT 2: Orthographic projections 4 lectures
Orthographic Projections - Principles of Orthographic Projections-Conventions - Projections of Points and lines inclined to both planes; Types of planes, Projection of planes parallel to one of the references. Projections of planes inclined to one of the reference planes and perpendicular to the other.
UNIT 3: Projection of solids and section of solids 4 lectures
Introduction and types of solid, Projections of solids in simple positions, inclined to both planes. Introduction and Section of prisms, Pyramids, Cylinder, Spheres, Cones
UNIT 4: Isometric projection 2 lectures
Introduction of isometric axes, lines and planes, Isometric drawing of different objects.
UNIT 5: Development of surface and perspective projection 2 lectures
Development of surfaces of right, regular solids – development of prisms, cylinders, pyramids, cones and their parts. Principle of perspective projections, Definition of perspective elements.
UNIT 6: Computer graphics 1 lectures
Engineering Graphics Software; -Spatial Transformations; Orthographic Projections; Model Viewing; Co-ordinate Systems; Multi-view Projection; Exploded Assembly; Model Viewing; Animation; Spatial Manipulation; Surface Modelling; Solid Modelling;

List of lab Exercises: **Total Session: 15** **Each Session: 2 hours**

1	Introduction to CATIA, user interface and sketching tools.
2	Introduction to engineering Graphics, sheet layout and sketching. Drawing of Lines, Lettering, Dimensioning
3	Orthographic projection
4	Projection of points situated in 1st, 2nd, 3rd and 4th quadrant
5	Projection of Line parallel to one or both the planes, line perpendicular to one plane and parallel to other
6	Projection of Line inclined to both the reference planes.
7	Projection of planes parallel to one of the references.
8	Projection of planes parallel to inclined to one of the references.
9	Introduction and types of solid, Projections of solids, Projections of solids in simple positions.
10	Projections of solids Inclined to one plane.
11	Section of solids
12	Section of solids
13	Isometric drawing of different objects
14	Methods of development, Developments of lateral surfaces
15	Principle of perspective projections

Text Books / Reference Books

1) Bhatt, N. D. *"Engineering Drawing"*, Charol Publication

2) Gill, P. S. *"Engineering Drawing"*, Kataria Publication

3) Dhawan, R. K. *"Engineering Drawing"*, S Chand

Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination

Examination Scheme:

Components	IA	Lab	End Sem	Total
Weightage (%)	**35**	**35**	**30**	**100**

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO 11	PO12
CO1	3	3	3	2	3	-	-	-	-	2	-	1
CO2	3	3	3	2	3	-	-	-	-	2	-	1
CO3	3	3	3	2	3	-	-	1	-	2	-	1
CO4	3	3	3	2	3	-	-	1	2	2	-	1
Average	**3**	**3**	**3**	**2**	**3**	**-**	**-**	**1**	**2**	**2**	**-**	**1**

1 = weakly mapped, 2 = moderately mapped, 3 = strongly mapped

CHCE1002	Process Chemistry	L	T	P	C
		3	0	0	3
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

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

CO1. Understanding fuels, hydrocarbons, and nanomaterials, water chemistry, electrochemistry, catalysis, polymerization, and corrosion.

CO2. Explain the concepts regarding fuels, hydrocarbons, and nanomaterials, water chemistry, electrochemistry, catalysis, polymerization, and corrosion.

CO3. Apply the concepts of process chemistry to solve real life problems.

Course Description

In the course, the students will learn about fuels, their properties and how to analyze them. Additionally, they will learn about fundamentals of electrochemistry by covering concepts related to conductance. The students will also study energy storage systems like batteries based on lithium, cobalt etc. The course also covers important topics such as Adsorption chemistry, Polymers (types, properties, and uses), and nanomaterials (synthesis, characteristics, properties, and quantum dots).

Course Content

Unit 1: Fuels and Thermochemistry (Chemistry, Applied Sciences Cluster) 8 Hours

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, non-conventional fuels- hydrogen fuel, solar fuel, wind energy, methane hydrates, biofuels (biodiesel, biogas, bioethanol). Petroleum vs. Natural gas.

Hydrocarbons chemistry: Basic concepts for preparation strategy, chemical properties, and reactivity of aliphatic (alkanes, alkenes, alkynes, cycloalkanes) and aromatic hydrocarbons.

Unit 2: Electrochemistry and Corrosion (Chemistry, Applied Sciences Cluster) 8 Hours

Nernst equation (for half-cell and complete cell), 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.

Energy storage systems: Introduction, classification -primary, secondary, and reserve batteries. Ni-MH and Li, Co, Fe and Ga-ion batteries- construction, working, applications, advantages, and limitations.

Unit 3: Adsorption chemistry (Energy Cluster) 8 Hours

Forces and energetics of adsorption; Adsorption equilibrium (including both single and multicomponent systems); Catalyst design and synthesis, Adsorbent materials (with emphasis on zeolites and activated carbon); Sorption kinetics and measurement of transport properties; Adsorption Column Dynamics (including linear, non-linear and multicomponent/non-isothermal systems); Adsorption Separation processes (choice of regeneration methods, pressure swing, thermal swing, and displacement processes. Membrane Processes.

Unit 4: Water chemistry (Chemistry, Applied Sciences Cluster) 6 Hours

Introduction, hardness of water, measurement of hardness, alkalinity, water softening- lime-soda process, zeolite process, ion exchange process. Water pollution and water splitting.

Unit 5: Polymers (Energy Cluster) 8 Hours

Types of polymerization techniques: Bulk, solution, suspension and emulsion, mechanism of polymerization (cationic, anionic, and free radical), co-polymerization and mechanism, 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, airtight containers, cook-wares, cold drink bottles; Biopolymers: carbohydrates, proteins, and lipids, conducting polymers.

Unit 6: Nanomaterials (Chemistry, Applied Sciences Cluster) 7 Hours

Introduction, Characteristics, Methods of preparation: precipitation, co-precipitation, sol-gel, hydrothermal, microemulsion. Introduction to characterization techniques. Properties: optical, electrochemical, sensing; Application of nanomaterials. Quantum dots -properties and applications

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. Krishnamoorthy. Publisher: New Delhi: McGraw Hill, 2012, Edition: 1. ISBN: 9780071328753.

Modes of Evaluation:

Components	**Lab**	**Theory**		
	Continuous Evaluation	**IA**	**Mid Semester**	**End Semester**
Weight %	-	50	20	30

Relationship between the Program Outcomes (POs), Program Specific Outcomes (PSOs) and Course Outcomes (COs)

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	P10	P11	P12	PSO1	PSO2
CO1	3	2	2										2	1
CO2	3	2	2										2	1
CO3	3	2	2										2	1
Average	3	2	2										2	1

1. WEAK 2. MODERATE 3. STRONG

CHCE1101	**Process Chemistry Lab**	**L**	**T**	**P**	**C**
		0	**0**	**2**	**1**
Pre-requisites/Exposure	12^{th} Chemistry				
Co-requisites					

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 percentage of moisture, volatile matter, ash content, and fixed carbon in a given coal sample by proximate analysis.
2. To estimate sulfur content in a given sulfate solution of sodium sulfate gravimetrically.
3. To determine the strength of a given solution of NaOH by titrating it against standard oxalic acid solution using phenolphthalein.
4. Adsorption of acetic acid by activated charcoal.
5. To determine the strength of the given solution conductometrically.
6. To determine the strength of the given solution potentiometrically.
7. To determine the and total hardness of the water sample.
8. To determine the alkalinity of a given water sample.
9. To prepare and characterize Urea-Formaldehyde (UF) resin.

To prepare N/30 ferrous ammonium sulphate solution and to determine the strength of given ferrous ammonium sulphate solution using potassium dichromate as intermediate solution and diphenyl amine as internal indicator.

Textbooks:

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	-	-	-	-	-

1=Weakly mapped 2= Moderately mapped 3=Strongly mapped

CHCE2028	**Chemical Technology**	**L**	**T**	**P**	**C**
		2	**0**	**0**	**2**
Pre-requisites/Exposure	Engineering Mathematics I, Physics, 12^{th} Chemistry				
Co-requisites	Process Chemistry				

Course Objectives:

1. To introduce students to the sources of various chemicals
2. To learn the different unit processes and operations involved.
3. To understand the manufacturing processes of many important chemicals such as sulphur, silicates, chlor-alkali chemicals, fertilizers, etc.
4. To understand the flow diagrams of these manufacturing processes.
5. To learn about the various petroleum compounds, and synthesis of petrochemical products.

Course Outcomes:

CO1: Understanding the stoichiometry, unit processes, unit operation, and various organic and inorganic chemicals.

CO2: Applying the concept of stoichiometry and unit operations in the synthesis of chemicals of various industries like chloro-Alkali, nitrogen, Sulphur, pulp and paper, and petroleum products.

CO3: Analysis of chemical engineering concepts used in these processes.

CO4: Evaluating the existing processes for their production efficiencies, environmental impact, and commercial viability.

Course Description:

This subject deals with the unit operations and unit processes occurring in various chemical industries. It also covers the learning of various flow charts depicting various unit operations and processes involving chloro-alkali, nitrogen, sulfur, fermentation, paper, and petroleum industries, respectively. This course also gives a brief overview of Indian chemical industries and the challenges faced during its operation.

Course Curriculum:

Unit 1: Introduction: Chemical industries, facts and figures, unit operation and unit process concepts, chemical processing, and role of chemical engineers	3 Hours
Unit 2 – Chloro-Alkali Industries: Soda ash, Solvay process, dual process, natural soda ash from deposits, electrolytic process, caustic soda. Nitrogen Industries: Ammonia, nitric acid, urea from ammonium carbonate, Ammonium nitrate.	8 Hours
Unit 3 – Sulfur and sulfuric industries: elemental sulfur mining, by Frasch process, sulfur production by oxidation reduction of H2S, sulfur and sulfur dioxide from pyrites, sulfuric acid contact process, chamber process. Fermentation Industries: Ethyl alcohol by fermentation, fermentation products from petroleum.	8 Hours
Unit 4 - Pulp and Paper Industries: Sulfate pulp process, chemical recovery from sulfate pulp digestion liquor, types of paper products, raw materials, methods of production.	3 Hours
Unit 5 - Petroleum Processing: Production of crude petroleum, petroleum refinery products, types of refineries, design of refinery, choice of crude petroleum, refinery processes, pyrolysis and cracking, reforming, polymerization, Isomerization, alkylation.	6 Hours

Textbooks:

1. M. Gopala Rao, Marshal Sittig, "Dryden's Outlines of Chemical Technology" 3rd Edition, East West Press.
2. Austin G.T, Shreve's Chemical Process Industries – International Student Edition, 5th Edition, McGraw Hill Inc.,1998

Reference Books:

1. S.D. Shukla and G. N. Pandey, "Textbook of Chemical Technology", Vol. I, 1977

CO/PO mapping of 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

CHCE2029	Material and Energy Balance Calculations	L	T	P	C
		2	0	0	2
Pre-requisites/Exposure	Engineering Mathematics I, Physics				
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 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. Understand the concept of physical quantities, unit conversion, stoichiometry, vapor/liquid equilibria, crystallization, and humidification.
CO2. Solve 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	4 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	10 Hours
Unit 3: Gases, Vapors and Liquids: Vapor pressure, Cox chart, Duhring's plot	3Hours
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	9 Hours
Unit 5: Crystallization, Dissolution; Humidity and Saturation, humid heat, humid volume, dew point, humidity chart and its use	4 Hours

Textbooks:

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

SLICL 002	LIVING CONVERSATIONS	L	T	P	C
		2	0	0	2
Pre-requisites/Exposure	--				
Co-requisites	--				

Course Objectives:

The objectives of this course are:

- Encourage critical self-reflection to develop empathy and clarity of expression fortheexchange of individual and organizational ideas and information.
- Enable qualities of deep listening and clear and concise communication skills.
- Apply and practice varied platforms and tools of communication both formal and informal.
- Appreciate and practice collaborative communication in a given environment and context.

Course Outcomes:

CO 1	**Understand** the importance of being an empathetic communicator and the role of clarity in the expression.
CO 2	**Use and Analyze** communication strategies and theories, as well as how they are practiced in the professional and social environment.
CO 3	**Demonstrate** appropriate tools to improve one's ability to express, listen, and understand people in a given situation and context.
CO 4	**Articulate** responses both verbally and non-verbally for group and individual work undertaken by self and by others, in the execution of the project/coursework.
CO5	**Practice and Employ** communication skills to engage ethically in independent and life-long learning in the broader context.

Course Descriptions: Living Conversations is a life skill course that empowers and enables learners to exchange, empathize, express, ideate, create, and collaborate in any given situation -professional or personal. It aims to enable students to converse confidently and participate in a variety of discussions appropriately in different situational and cultural contexts, making theminfluential communicators.

Course Curriculum:

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1. **Basics of Communication** **4 hours**

Introduction to the course, Importance, use and its application in life (personal as well as professional), Basics of Communication with Practical Examples (need – principles - process – model), Introducing Types of Communication (Verbal & non-verbal), Types of non-verbal communication & its importance in overall communication.

2. **Setting Communication Goals & Avoiding Breakdowns** **6 hours** Communication goals, creating value in conversations, Internal & external factors impactingour conversations, Communication breakdowns, and how to address them.

3. **Listening for Improved Understanding** **2 hours**Importance, Active & Passive listening, Barriers, Benefits, Features & Examples of Active Listening, Verbal and non-verbal signs of active listening skills, Tools & Tips for Practicing Active Listening.

4. **Non-verbal Communication** **6 hours**
Introduction to Non-Verbal Communication, Areas of nonverbal communication, Functions and influence of nonverbal communication, Basics of Body Language, Common Gestures, Body Language Mistakes, Improving Your Body Language, Voice Modulation.

5. **Public Speaking and Presentation Skills** **4 hours**

Public Speaking vs. Presentations, The Essentials of Effective Presentation, Content Development, Confidence Building, Best Practices, Virtual Presentation.

6. **Communication Styles** **2 hours**

Recognizing your style and the styles of others, closing communication gaps, and being flexible without compromising one's identity.

7. **Cross-cultural Communication: Navigating beyond boundaries** **2 hours**Developing greater sensitivity to cultural differences, Building greater accountability and trust on virtual teams, Uncovering hidden assumptions, and Recognizing filters in oneself andothers.

PROJECT WORK and Submission **4 hours**

Textbooks

- Hargie, Owen (ed.) (2018). The Handbook of Communication Skills. Routledge. London.

- Anderson, Peter & Guerrero, Laura. Handbook of Communication and Emotion. 1stEdition. Elsevier.
- Bordia Crossman, Bretag. Communication Skills. Tata Macgraw Hill.
- Tuhovsky, Ian. The Science of Effective Communication.
- Murphy, Herta, Thomas, Jane P. Effective Business Communication. Tata MacGraw Hill

References:

- Patterson, Kerry et al. (2011) Crucial Conversations Tools for Talking When Stakes AreHigh. MacMillan. Switzerland.
- A Theory of Goal-Oriented Communication: https://www.researchgate.net/publication/220138297_A_Theory_of_Goal-Oriented Communication
- Effective Communication http://www.free-management-ebooks.com/dldebk/dlcm-effective.htm
- Active Listening http://www.free-management-ebooks.com/dldebk/dlcm-active.htm
- **TED Talks:** https://www.ted.com/playlists/211/the_art_of_meaningful_conversa

CO/PO Mapping for the course:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	1	-	1	1	1	1	-	1	1	1	1
CO2	-	2	1	-	2	1	1	-	2	3	1	1
CO3	-	1	1	-	2	-	1	1	1	3	1	1
CO4	-	-	1	-	2	1	1	1	2	3	-	1
CO5	-	2	-	2	3	-	-	1	2	1	-	2
Average	-	**1.2**	**0.6**	**0.6**	**2**	**0.6**	**0.8**	**0.6**	**1.6**	**0.4**	**0.6**	**1.2**

1. Weak Mapped 2. Moderate Mapped 3. Strong Mapped

Course Code	Course Name	L	T	P	C
SSEN0102	**Environment Sustainability and Climate Change (Living Lab)**	**2**	**0**	**0**	**2**
Pre-requisites/Exposure	Fundamentals of basic Environment Sustainability and Climate Change				
Co-requisites					

Course Objectives (CO) :

V. Understand the concept of Living Labs and their application in the environmental sustainability.
W. Develop a critical understanding of the nature, cause and impact of human activities on the environment.
X. Apply design thinking and innovative principles to develop sustainable solutions.
Y. Evaluate and address legal, policy and ethical consideration in environmental research.

Course Outcomes

CO-1: Gained practical skills in stakeholder engagement, environmental data collection and analysis.
CO-2: Develop expertise in designing and managing Living Lab for environmental sustainability and climate action.
CO-3: Acquired hands on experience with environmental monitoring tools and technologies.
CO-4: Enhance the ability to think critically and creatively in developing sustainable solutions.

Catalogue Description

This course offers a unique learning experience that blends theory and practice in the dynamic field of living labs. Students will engage with real-world challenges, collaborate with external stakeholders, and develop innovative solutions. Through hands-on projects and case studies, participants will gain the skills and knowledge needed to thrive in today's innovation-driven environments. This course is suitable for students interested in fields such as urban planning, technology development, social sciences, and business, as it provides a multidisciplinary perspective on the concept of living labs and their impact on communities and industries. The syllabus provide students with a storing foundation in using Living Lab to addressing pressing environmental challenges and contribute to sustainable solution in the context of climate change.

Course Content

1. A two-credit course in practicum or lab work, community engagement and services, and field work in a semester means two-hour engagement per week. In a semester of 15 weeks duration, a one credit practicum in a course is equivalent to 30 hours of engagement.

2. **Case Studies and Field Work**

The students are expected to be engaged in some of the following or similar identified activities:

Discussion on one national and one international case study related to the environment and sustainable development.

Examples: Bhopal Gas Tragedy, Chipko Movement, Narmada Valley Projects, National Park, Sanctuaries, Biosphere Reserve, London Smog 1952, Air Pollution in Delhi, Case studies on Current Environmental Issues, Oil Spills – Deep Water Horizon Oil Spill, BP Oil Spill etc.

3. **Field Visit**

Field visits to identify local/regional environmental issues, make observations including data collection and prepare a brief report.

4. Campus Environmental Management.

Campus environmental management activities such as solid waste disposal, water management, and sewage treatment.

Group Project: Students are required to submit group projects on various topics related to environmental pollution, climate change, biodiversity, natural resource and sustainable development.

Broadly, Living Lab may falls in one of seven thrust areas:

1. **Indigenous technology and Traditional Ecological Knowledge (TEK)**

   The project aims to document, preserve and revitalize Traditional Ecological Knowledge (TEK) held by indigenous communities. TEK encompasses the deep understanding of local ecosystems, sustainable solution resource management practices and cultural connection to environment. This project emphasizes a collaborative approach involving indigenous elders, community members and researcher. The project not only respects and preserves the rich cultural heritage of indigenous communities but also harnesses their valuable ecological knowledge to address contemporary environmental challenges and promote sustainable practices. It emphasizes the importance of community-driven conservation efforts and the recognition of TEK as a valuable source of ecological wisdom.

2. **Climate change and its impact on Bird Migration**

   In recent years, climate change has been affecting the migration patterns of many bird species worldwide. This project aims to study and mitigate the impact of climate change on avian migration and contribute to conservation efforts. This project not only addresses the ecological impact of climate change but also contributes to the conservation of bird species that play vital roles in ecosystem health and biodiversity. It emphasizes the importance of interdisciplinary collaboration and community engagement in tackling climate-related ecological challenges. This project will focus on developing targeted conservation strategies to mitigate the impact of climate change on bird population and help in enhancing collaboration among scientists, conservationists, and local communities for bird conservation.

3. **Sustainable Communities**

How can co-production and social learning with stakeholder communities help us understand how climate action can be implemented 'on the ground'?

The 'living lab' offer for active engagement with a diverse student body and neighborhood groups. It reflects the wider academic recognition that universities are significant economic, social and environmental catalysts for cities and regions, offering the potential for change at a spatial scale that connects the local with the global. Project activities to empower the local community-based people to enhance their lifestyle by doing activities. For example, we can do a few projects like utilization of Himalayan biomass for various uses. Our students can give this training and awareness program to localities.

- We can work on the SMART village project by following the SDG goals given by United Nations.
- Identification and selection of such communities who have some native or ancestral knowledge. For example, one farmer in Kerala has huge seed bank from the very old time (more than 200 Years).
- Projects in this area will explore how meaningful policy change can be driven in expanding circles from the level of university communities to the cities, states and nations they are embedded in.

4. **Ecology, Conservation, and Climate Change**

   Project within this domain will investigate the ecological characteristics of ecosystem undergoing degradation, examine the dynamics of shifts in parasite ecology and explore the enduring adaptation in hosts, parasites and explore the evolutionary adaptation in host, parasites and wildlife influenced by climate fluctuation and various environmental stressors. UPES can work on the preservation of untouched Himalayan flora and fauna and propose one flora and fauna bank. This may be followed by the several awareness program for the locals by our staffs and students. The primary aim of projects in this area will be to establish and sustain long-term studies of how climate change impacts ecological aspects of our natural world.

5. **One Health**

This project is centered around the concept of "One Health," which is an approach that recognizes the interconnectedness of human health, animal health, and the health of the environment. It aims to address the broader context of ecological health, acknowledging that various factors such as climate change, habitat alterations, and biodiversity loss play a significant role in shaping the overall health of ecosystems and, consequently, human health. In essence, this project seeks to broaden our understanding of health by looking beyond the human dimension and recognizing the intricate web of relationships that connect human health to animal health and the environment.

One of the primary concerns is to examine the potential sources of new zoonotic diseases. Zoonotic diseases are those that can be transmitted from animals to humans, and understanding their origins is crucial for preventing future outbreaks.

6. **Climate and society**

Climate action will require disruptive transformations for society, but how can that 'transformational intent' be developed? The digital revolution and data science show how rapid transformation can happen, history offers perspectives on such transformations in the past while the business world illuminates how rapid change continues to occur in the commercial and financial sector.

- ✓ This group of projects will study the interface between climate, sustainable living, and the forces that drive society and societal change.

7. **Communities Based Water Testing Kits and Soil Testing Kits and promotion of low cost water purification technologies**
   - ✓ Identify water borne disease in surrounding villages by conducting field surveys and sensitize local communities about water borne diseases and suggest low-cost water treatment methods.
   - ✓ Training local people for water and soil testing.
   - ✓ Sampling and analysis of drinking water

Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination

Components	Continuous Assessment	ESE
Weightage (%)	100	100

Correlation between the Course Outcomes (COs) and Program Outcomes (POs) Table :

PO/CO	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO
	1	2	3	4	5	6	7	8	9	10	11
CO1	2										
CO2	2	1			1						

CO3	3	1		1	2			1			2
CO4	2	2		1	1			1			1
Average	2.25	1.3		1	1.3			1			1.5

1=Weakly mapped 2= Moderately mapped 3=Strongly mapped

SEMESTER III

CSBA2013	Data Analytics and Machine Learning	L	T	P	C
Version 4.0		3	0	0	3
Pre-requisites/Exposure	Engineering Mathematics I and II, Object oriented programing				
Co-requisites	--				

Course Objectives

1. Understand the fundamental concepts and techniques of data analytics and machine learning.
2. Develop proficiency in data pre-processing, cleaning, and exploratory data analysis.
3. Gain knowledge of a wide range of supervised and unsupervised learning algorithms and their applications.
4. Learn to evaluate and validate machine learning models using appropriate performance metrics and cross-validation techniques.
5. Acquire skills in feature selection and engineering to improve model performance and interpretability.
6. Explore neural networks and deep learning algorithms for more complex machine learning tasks.
7. Learn about big data analytics and cloud computing platforms for handling large-scale data.
8. Develop an awareness of ethical considerations and bias in machine learning, and understand privacy and security issues.

Course Outcomes

On the completion of this course, the student will be able to:

CO1	Define and explain the terms as well as concepts involve in handling big data, its analysis, and learning algorithm
CO2	Compare various learning algorithms based on the strength and limitations.
CO3	Collect a data as well as prepare a big data set by applying data cleaning and transformation technique.
CO4	Analyze complex datasets and demonstrate the patterns, correlations, and its trend by using various learning algorithms

Course description

The Data Analytics and Machine Learning course provides a comprehensive understanding of data analytics and machine learning concepts and applications. Students will learn essential techniques for data pre-processing, exploratory data analysis, and feature engineering. They will explore supervised learning algorithms like linear regression, logistic regression, decision trees, and support vector machines for classification and regression tasks. Unsupervised learning algorithms, including clustering and dimensionality reduction, will be covered. Feature selection and model interpretability methods will be explored to enhance model performance and gain insights. The course introduces neural networks, deep learning, and their applications in image classification and natural language processing. Students will gain skills in time series analysis and forecasting. They will also learn about big data analytics and cloud computing platforms. Ethical considerations and biases in machine learning will be addressed.

Course Content

UNIT I: Introduction to Data Analytics and Machine Learning: Overview of data analytics and its importance, introduction to machine learning and its applications, key concepts, and terminology	**5 Hours**
UNIT II: Data Preprocessing and Exploratory Data Analysis: Data collection and cleaning, handling missing data and outliers, data transformation and feature engineering, exploratory data analysis techniques	**8 Hours**

Unit III: Supervised Learning Algorithms: Clustering algorithms (e.g., K-means, hierarchical clustering), Dimensionality reduction techniques (e.g., Principal Component Analysis, t-SNE), Association rule mining, Feature importance and selection techniques.	**8 Hours**
Unit IV: Unsupervised Learning Algorithms and Feature Selection: Clustering algorithms (e.g., K-means, hierarchical clustering), Dimensionality reduction techniques (e.g., Principal Component Analysis, t-SNE), Association rule mining, Feature importance and selection techniques. Performance metrics for classification and regression models, Cross-validation techniques, Hyperparameter tuning, Model interpretability and explainability	**8 Hours**
Unit V: Model Material Informatics: Materials Innovation Ecosystem: Multiscale Modeling and Multilevel Design of Materials, Multiscale Modeling and Multilevel design of Materials, Decision-Making in Material Design Multilevel System, Material knowledge and materials data science, Understand property, structure and process spaces, Process-Structure-Property Linkages, role of Data Science in Materials Knowledge System, Material structure and its digital representation, Dimensionality reduction techniques: Principal Component Analysis, Understand Homogenization and Localization concepts	**8 Hours**
Unit VI: Neural Networks: Introduction to neural networks, Multilayer perceptrons, Convolutional neural networks (CNNs), Recurrent neural networks (RNNs), Transfer learning, Natural Language Processing (NLP), Time series analysis, Ethical considerations, and bias in machine learning.	**8 Hours**

Textbooks

1. McKinney, W. (2017). Python for Data Analysis: Data Wrangling with Pandas, NumPy, and IPython. United States: O'Reilly Media.John Zelle, Python Programming: An Introduction to Computer Science
2. Hastie, T., Witten, D., James, G., Tibshirani, R. (2013). An Introduction to Statistical Learning: With Applications in R. Germany: Springer New York.
3. Bishop, C. M. (2006). Pattern Recognition and Machine Learning. Switzerland: Springer New York.

Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination
Examination Scheme:

Components	Internal Assessment	MSE	ESE
Weightage (%)	30	20	50

Co-Relationship Matrix

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	3	2	1	2	2	-	-	-	-	-	-	-	1	1
CO2	3	2	1	2	2	-	-	-	-	-	-	-	1	1
CO3	3	3	2	3	2	-	-	-	-	-	-	-	1	1
CO4	3	3	2	3	2	-	-	-	-	-	-	-	1	1
Avg	3	2.5	1.5	3	2	-	-	-	-	-	-	-	1	1

CHCE2021	Process Heat Transfer	L	T	P	C
		3	1	0	4
Pre-requisites/Exposure	Engineering Mathematics I and II				
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 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: Conduction – Introduction to Heat transfer; Analogies between transport processes; Modes of Heat Transfer; Fourier's Law; Newton Law of cooling; Stefan Boltzmann Law; 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+ 4 Hours
Unit 2: 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	9+3 Hours
Unit 3: Heat transfer with change of phase – Phenomena of boiling; Regimes of pool boiling; Nucleate boiling; Condensation; film condensation on a vertical surface and tubes	4 +1 Hours
Unit 4: 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	6+2 Hours
Unit 5: 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. Evaporators and its types, single and multiple effect evaporators and their design, evaporator capacity and economy.	14+5 Hours

Textbooks:

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

CHCE2003	Momentum Transfer	L	T	P	C
		3	1	0	4
Pre-requisites/Exposure	Engineering Mathematics I and II, Physics				
Co-requisites	Chemical Engineering Thermodynamics				

Course Objectives:

1. To introduce the fundamental aspects of the fluid flow behaviour.
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 mechanic's 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, NPSH calculations; Calculations using spreadsheets/MS Excel; Use Pipesim software for designing of pipeline systems.	15+5 Hours

Textbooks:

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

CHCE2002	Chemical Engineering Thermodynamics	L	T	P	C
		3	1	0	4
Pre-requisites/Exposure	Engineering Mathematics I and II, Physics				
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.
5. Apply concepts of thermodynamic to solutions and vapour liquid equilibria

Course Outcomes:

CO1. Understand the basics of thermodynamics, mass and energy conservation principle, potential functions, VLE and chemical reaction equilibria

CO2. Compute the thermodynamic properties of fluids, work, and heat, entropy, fugacity, VLE and equilibrium conversion.

CO3 Apply different thermodynamic model to describe the phase equilibria

CO4 Analyse the real-life systems based on thermodynamic principles.

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, Scope of thermodynamics, Thermodynamic systems; Basic concepts on Temperature, Pressure, Work, Energy, Heat, 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, Application of thermodynamics to flow processes-pumps, compressors, and turbines;	9+3 Hours
Unit 2: 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)	3+1 Hours
Unit 3: 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. The Carnot refrigerator; Vapor-compression cycle; Absorption refrigeration; Heat pump, Liquefaction processes	9+3 Hours
Unit 4: Thermodynamic property of fluids, Potential Functions, Maxwell relations, 2-phase systems; Clausious-Claypeyron Equation, 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.	9+3 Hours
Unit 5: 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, Liquid phase properties from VLE, Models for excess Gibbs energy, heat effects and property change on mixing; Calculations using tools like MS Excel/Spreadsheets.	9+3 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.	6+2 Hours

Textbooks:

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 textbook 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	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2
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

CHCE2103	Momentum Transfer Lab	L	T	P	C
		0	0	2	1
Pre-requisites/Exposure					
Co-requisites					

Course Outcomes:

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

Laboratory Manuals
Santosh K. Gupta, Momentum Transfer Operations, Tata McGraw Hill, New Delhi, 1979 (out of print)
Z. Gupta and S. K. Gupta, Fluid Mechanics and its Applications, 3rd Ed., New Age Intl Pub., New Delhi, 2016
AA. 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	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2
CO1	3	-	-	-	-	-	-	-	-	-	-	-	-	-
CO2	-	-	-	3	-	-	-	-	-	-	-	-	2	-
CO3	-	-	-	-	-	-	-	-	-	2	-	-	-	3
CO4	-	-	-	-	-	-	-	3	3	-	-	3	-	-
Avg	3	-	-	3	-	-	-	3	3	2	-	3	2	3

MECH2158	Heat Transfer Lab	L	T	P	C
		0	0	2	1
Pre-requisites/Exposure					
Co-requisites					

Course Outcomes:

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

Experiments List:

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.
Thermal Conductivity of Metal Rod - To determine the thermal conductivity of a metal rod using one-dimensional heat conduction equation.
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.
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.
Forced Convection - To determine the convective heat transfer coefficient for forced convection due to flow of air across the heated tube.
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.
Dropwise and film wise condensation - To study the rate of condensation and heat transfer coefficient.

Reference Books:

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

CO/PO Mapping for the course:

PO/CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2
CO1	3	-	-	-	-	-	-	-	-	-	-	-	-	-
CO2	-	-	-	3	-	-	-	-	-	-	-	-	2	-
CO3	-	-	-	-	-	-	-	-	-	2	-	-	-	3
CO4	-	-	-	-	-	-	-	3	3	-	-	3	-	-
Avg	3	-	-	3	-	-	-	3	3	2	-	3	2	3

SLLS0201	Design Thinking	L	T	P	C
		1	0	0	2
Pre-requisites/Exposure	--				
Co-requisites	--				

Course Objectives:

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

Course Outcomes:

CO1	Understand human centered design/problem solution
CO2	Explore and apply design thinking process by using tools that are collaborative, innovative and effective
CO3	Develop a framework for solving complex problems
CO4	Learning by doing, engaging, exploring and experimenting

Course Descriptions:

The evolution of design has transformed it from a discipline confined to a singular, specific domain into a versatile tool for tackling intricate, nonlinear challenges. Design thinking has emerged as a skill that empowers individuals to confront uncertainty, complexity, and failure. By introducing theoretical principles and analyzing real-world industry examples, the course explores design thinking as a process that involves understanding the context (the thinking phase), creating tangible prototypes (the making phase), and testing potential solutions (the breaking phase). The course further emphasizes the productive value of iterating through this process rapidly and frequently (the repeating phase) to enhance ideas and cultivate fresh insights.

Course Curriculum:

Unit 1: Innovation through Design: Think, Make, Break, Repeat — 8 Hours
Introduction to design thinking, its importance and application in life through theory and real-life examples from industry and different walks of life.

Unit 2: The Design Thinking Approach — 8 Hours
Exploring the principles, mind-set, and process of design thinking. Understanding the importance of empathy and placing the user at the centre in the design process and learning techniques for conducting user-centered research for creating solutions that address users' needs and pain points.

Unit 3: Problem Framing — 8 Hours
Techniques for identifying and framing the right problem to solve through Design Thinking. Strategies for generating creative ideas and facilitating effective brainstorming sessions to explore a wide range of possibilities.

Unit 4: The Designer Mentality — 6 Hours
Understanding the iterative design process and exploring prototyping methods and techniques for rapidly building and testing prototypes to gather feedback, iterate on designs, refine and improve solutions. Applying Design Thinking principles to create intuitive and delightful user experiences.

Textbooks:

3. Burnett, B., & Evans, D. (2023). Designing your new work life. Vintage.
4. Burnett, B., & Evans, D. (2022). *Designing your life: How to build a well-lived, joyful life*. Alfred A. Knopf.

Reference Books:

3. Burnett, W., & Evans, D. J. (2020). Designing your work life how to thrive and change and find happiness at work. Chatto & Windus, an imprint of Vintage

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	1	-	-	-	-	-	1	-	3	-	-
CO2		1	1	-	1	-	-	-	3	2	-	-	-	-
CO3		1	1	2	-	-	-	-	-	-	-	3	-	-
CO4		1	1	2	1	-	-	-	3	2	-	3	-	-
Avg		1	1.25	1.25	0.5	-	-	-	1.5	1.25	-	2.25	-	-

SEMESTER IV

CHCE2019	Numerical Methods in Chemical Engineering	L	T	P	C
		3	1	0	4
Pre-requisites/Exposure	Engineering 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	2 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	9+3 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+3 Hours
Unit 4: Interpolation and Approximation, Newton's polynomials and Lagrange polynomials, spline interpolation, linear regression, polynomial regression, least square regression	6+2 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	6+2 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+3 Hours
Unit 7: Introduction to Partial Differential Equations: Characterization of PDEs, Laplace equation, Heat conduction/diffusion equations, explicit, implicit, Crank-Nicholson method.	3+1 Hours

Textbooks:

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

CHCE2017	Mass Transfer	L	T	P	C
		3	1	0	4
Pre-requisites/Exposure	Material and Energy Balance computations, Chemical Engineering Thermodynamics				
Co-requisites					

Course Objectives:

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

Course Outcomes:

CO 1	Understanding the fundamentals of mass transfer operation
CO 2	Apply the mass transfer principles for basic calculations (diffusivity, mass transfer coefficient, reflux ratio, drying time etc.)
CO 3	Solve the material and energy balance problems in different mass transfer operation
CO 4	Design and evaluate the performance of mass transfer equipment

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	5+1 Hours
Unit 2: Convective and Interphase 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, 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	7+2 Hours
Unit 3: Gas Liquid contacting equipment; Basic design of tray columns; Tray column behavior (flooding; entrainment; weeping; coning etc.), Relative volatility; Batch Distillation process; Flash Distillation; Continuous Distillation process (Mc-Cabe Thiele Method), Reflux ratio, design of distillation column. Gas Absorption fundamentals; Counter-current multistage absorption process; Continuous- Contact Equipment; Design of Gas Absorption systems.	12+4 Hours
Unit 4: Liquid-Liquid Extraction and Leaching: Introduction to Liquid-Liquid Extraction; Ternary diagram; Single staged extraction process; multi-staged extraction process; liquid-liquid extraction equipment's, Introduction to Solid Liquid extractions; Single staged extraction process; multi-staged extraction process	9+3 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	9+3 Hours
Unit 6: 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;	4+1 Hours

Textbooks:

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	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2
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

CHCE2030	Chemical Reaction Engineering	L	T	P	C
		3	1	0	4
Pre-requisites/Exposure	Process Chemistry, Material and Energy Balance calculation				
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. Analyse experimental kinetic data to determine reaction mechanisms.
3. Analyse the RTD data for non-ideal reactors.
4. Design different types of ideal and non-ideal reactors (Batch, Tubular, and CSTR).

Course Outcomes:

CO1. Understanding the fundamentals of reaction, kinetics and ideal and non-reactor.
CO2. Solve the rate equations and RTD using ideal and non-reactor data and use modern tools.
CO3. Analyze the ideal reactors for multiple reactions.
CO4. Design ideal and non-ideal reactor systems

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, reaction rate fundamentals - elementary reaction, order of reaction mechanism, steady state approximation and rate limiting step theory	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	9+3 Hours
Unit 3: Ideal reactors - generalized material balance, design equations, 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 4: Multiple reactions - conversion, selectivity, yield, series, parallel, independent, and mixed series-parallel reactions; Calculation using tools like MS Excel/Spreadsheets	3+1 Hours
Unit 5: Introduction to non-ideal flow; Residence Time Distribution (RTD); E and F distribution curves; Solution using MS Excel/Spreadsheets; Compartment models; Dispersion models; Tank-in-series model; Earliness of mixing, segregation and RTD; Solution using MS Excel/Spreadsheets	15+5 Hours

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

CHCE2111	Mass Transfer Lab	L	T	P	C
		0	0	2	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 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

CHCE2130	Chemical Reaction Engineering Lab	L	T	P	C
		0	0	2	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	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2
CO1	3	-	-	-	-	-	-	-	-	-	-	-	-	-
CO2	-	-	-	3	-	-	-	-	-	-	-	-	2	-
CO3	-	-	-	-	-	-	-	-	-	2	-	-	-	3
CO4	-	-	-	-	-	-	-	3	3	-	-	3	-	-
Avg	3	-	-	3	-	-	-	3	3	2	-	3	2	3

CSEG1030	Programming	L	T	P	C
Version 4.0		1	0	1	1
Pre-requisites/Exposure	Engineering Mathematics I and II, Object Oriented Programing				
Co-requisites	--				

Catalog Description
This is a hands-on basic introductory course on python programming. Python is an open source, interpreted, object-oriented, high-level programming language. Global organizations such as Facebook, Reddit, Netflix, Spotify, Dropbox, Instagram, Uber, and Mozilla, have extensively used python programming to develop their website, apps, and software. Python is equipped with huge library of modules or package that are design for numerical computing, graphical user interface, gamming, drawing, data science, artificial intelligence, and machine learning. Moreover, python is comparatively easy to learn, requires lesser number of program lines, and has a huge community-based support. The advantage of open source, ease in learning and its huge extensive libraries have made python as one of the most popular programming languages in the world. In the present introductory course, we will learn the basic knowledge of python programming to explore its scope in the areas of scientific computing, drawing, graphical user interface, artificial intelligence, and machine learning.

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

CO 1 Understand the python syntax and define various data types.
CO 2 Identify and interpret the flow of program execution in a python code
CO 3 Develop python codes using in-built/user-defined functions and libraries to solve problems relating to chemical, refining and petrochemical plant.
CO 4 Analyze a python code and perform debugging to identify as well as fix code errors.

Course content

Unit 1: Introduction to basics of python programming: Why python programming? Installation of Python (*ver* 3.11.2) and integrated development environment (IDE). Working with the interface of IDE. Basic data types in python (none, numeric, sequences, and dictionary) and their conversions, basic operations (arithmetic, assignment, relational, logical, and unary) using in-built functions, binary conversions and bit-wise operations, concept of 2's compliment.	**6 hours**
Unit 2: Conditional statements and loops If, else, and elif, nested statements, the concept of debugging and errors, working with while and for loops, other statements such as break, continue and pass. The concept of incremental programming and printing of various shapes of star patterns.	**6 hours**
Unit 3: Math module and its in-built function, user defined functions. Creating drawings of basic shapes in python, introduction to object and classes in object-oriented programming (OOP).	**4 hours**
Unit 4: Introduction to Array in python	**8 hours**
Unit 5: Introduction to Machine Learning packages in python	**6 hours**

Textbooks
1. Dr. Charles Russell Severance (Author), Sue Blumenberg (Editor), Elliott Hauser (Editor), Aimee Andrion (Illustrator), Python for Everybody: Exploring Data in Python 3, ISBN: 1530051126.
2. Eric Matthes, Python Crash Course, 2nd Edition: A Hands-On, Project-Based Introduction to Programming, ISBN: 1593279280.

Suggested online links:
1. Official websites of python for software and basic in-built functions (https://www.python.org/)

2. NPTEL course on "The joy of computing using python", by Prof. Sudarshan Iyengar, IIT Ropar. (https://nptel.ac.in/courses/106106182).
3. Coursera course on "Python basics", University of Michigan (https://www.coursera.org/learn/python-basics/home)

Modes of Evaluation: Mid-semester, end-semester, and internal assessment (Quizzes/Assignments/ presentations/ extempore/ Written Examinations)

Relation between the Course Outcomes (COs) and Program Outcomes (POs)

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	3	2	2	3	3	-	-	-	-	-	-	-	1	1
CO2	3	2	2	3	3	-	-	-	-	-	-	-	1	2
CO3	3	3	2	3	3	-	-	-	-	-	-	-	1	3
CO4	2	3	2	3	3	-	-	-	-	-	-	-	1	1
Avg	2.8	2.5	2	3	3	-	-	-	-	-	-	-	1	1.75

SEMESTER V

		L	T	P	C
CHCE3050	**Advanced Reaction Engineering**	**3**	**0**	**0**	**3**
Pre-requisites/Exposure	Chemical Reaction Engineering, Momentum transfer				
Co-requisites					

Course Objectives:

1. To understand the catalysts and catalytic reactor systems
2. To develop understand of fluid particle interactions.
3. To understand the hydrodynamic behaviour of G/L and G/L/S systems
4. To be able to identify suitable reactors for different heterogenous systems.
5. To understand micro-reactors

Course Outcomes:

CO1. Apply reaction engineering principles to solve problems related to heterogeneous reactions.
CO2. Analyze different heterogeneous reaction systems and develop rate kinetics.
CO3. Evaluate different heterogeneous systems to select the desired reactors.
CO4. Design different heterogenous reactor systems

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: Catalysis and catalytic reactors: definition, properties and classification of catalyst, steps in a catalytic reaction, synthesizing a rate law, the rate equation for surface kinetics, Pore diffusion resistance combined with surface kinetics, The rate and performance equations.	12 Hours
Unit 2: Fluid particle reaction kinetics: Shrinking core model	6 Hours
Unit 3: Hydrodynamics – introduction to hydrodynamics; G/L and G/L/S hydrodynamic systems; superficial velocities; flow regimes; Thiele modulus and Damköhler coefficient	12 Hours
Unit 4: Reactors: Bubble column; Artificial lift, trickle bed; fluidized bed; Packed bed etc.	9 Hours
Unit 5: Micro reactors – Introduction monolith reactors; capillary reactors etc.	6 Hours

Textbooks:

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
Avg	2.8	2.7	3	3	3	-	-	-	-	-	-	-	2.8	3

CHCE3053	Advanced Separation Process	L	T	P	C
		3	0	0	3
Pre-requisites/Exposure	Mass Transfer				
Co-requisites					

Course Objectives:
1. To introduce students the advanced separation techniques apart from the conventional processes like distillation, absorption etc.
2. To enable the students to gain knowledge on adsorption, membrane separation processes, and other new processes.
3. To understand the concepts that involve electric field assisted separation process, chromatographic separation processes
4. To create awareness about advanced industrial effluent treatment methods.

Course Outcomes: At the end of the course, the students will be able to
CO1. Identify various advanced separation processes used in chemical industry.
CO2. Differentiate between adsorption and membrane separation.
CO3. Analyse the principles of chromatographic separations and electrodialysis.
CO4. Illustrate various inorganic separation processes.
CO5. Evaluate the performance of supercritical fluid extraction and effluent treatment processes.

Course Descriptions:
Separation processes are integral unit operation in most of the modern chemical, pharmaceutical and other process plants. Among the separation processes, some are standard and conventional processes, like, distillation, absorption, adsorption, etc. These processes are quite common, and the relevant technologies are well developed and well-studied. On the other hand, newer separation processes, like, membrane-based techniques, chromatographic separation, super critical fluid extraction, etc., are gaining importance in modern days plants. The present course is designed to emphasize on these advanced separation processes.

Course Curriculum:

Unit I: Basics of separation processes
Review of conventional processes, Recent advances in Separation Techniques based on size, surface properties, ionic properties and other special characteristics of substances, Process concept, Theory and Equipment used in cross flow Filtration, cross flow Electro Filtration, Surface based solid liquid separations involving a second liquid. **9 Hours**

Unit II: Membrane separations
Types and choice of Membranes, Plate and Frame, tubular, spiral wound and hollow fiber membrane modules, Membrane Reactors, and their relative merits, Commercial, Pilot Plant and Laboratory Membrane permeators involving Dialysis, Reverse Osmosis, Nanofiltration, Ultra filtration and Micro filtration, Ceramic- Hybrid process and Biological Membranes. **9 Hours**

Unit III: Chromatographic separations
Types and choice of Adsorbents, Adsorption Techniques, Recent Trends in Adsorption. Principle behind chromatographic separations, Affinity Chromatography and Immuno Chromatography, Industrial applications of chromatography. **9 Hours**

Unit IV: Inorganic separations
Controlling factors, Applications, Types of Equipment employed for Electrophoresis, Dielectrophoresis, Ion Exchange Chromatography and Eletrodialysis, EDR, Bipolar Membranes. **9 Hours**

Unit V: Other techniques
Separation involving Lyophilisation, Pervaporation and Permeation Techniques for solids, liquids and gases, zone melting, Adductive Crystallization, other Separation Processes, Supercritical fluid Extraction, Industrial Effluent Treatment by Modern Techniques. **9 Hours**

Text/ Reference books:

1. J. D. Seader and E. J. Henley, Separation Process Principles, 2nd Ed., Wiley, New York, 2006
2. Handbook of membrane separations by Pabby, Rizvi & Sastre, 2nd Edition, CRC Press, taylor & Francis Group, 2015
3. Environmental Engineering by Peavy, Rowe and Tchobanoglous, McGraw Hill, 1985
4. Separation process principles by Seader, Henley & Roper, 3rd Edition, John Wiley & Sons Inc., 2011
5. Principles of Mass Transfer and Separation Processes by B.K. Dutta, PHI, 2007
6. Membrane separation processes by Kaushik Nath, 2nd Edition, PHI, 2017.

Co-Relationship Matrix

Indicate the relationships by1- Slight (low) 2- Moderate (Medium) 3-Substantial (high)

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	-	-	-	-	3	-	-	-	-	-	3	3
CO2	2	2	-	-	-	-	3	-	-	-	-	-	3	3
CO3	2	2	-	-	-	-	3	-	-	-	-	-	3	3
CO4	2	2	-	-	-	-	-	-	-	-	-	-	3	3
CO5	3	3	-	-	-	-	-	-	-	-	-	-	3	3
Avg	2.2	2.2	-	-	-	-	3	-	-	-	-	-	3	3

CHCE3054	Energy Sources	L	T	P	C
		2	0	0	2
Pre-requisites/Exposure					
Co-requisites					

Course Objectives:
1. To make students aware of energy demand and supply.
2. To make students differentiate between conventional and non-conventional sources of energy from sustainability viewpoint.
3. To acquaint students with various sources of energy including renewable sources.
4. To create awareness about energy storage and their types.

Course Outcomes: At the end of the course, the students will be able to
CO1. Identify various types of energy storage including hydrogen storage.
CO2 Quantify current energy demand and supply.
CO3. Explore the potential of wind and solar energies along with their combination.
CO4. Evaluate the potential of nuclear and geothermal energies along with their integration.
CO5. Design an equipment related to energy production from biomass or hydrogen.

Course Descriptions:

The course covers various sources of energy including renewable 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 and storage have also been covered along with safety. Conversion of biomass to energy have also been addressed. Finally, various types of energy storage including hydrogen storage are covered in this course.

Course Curriculum:

Unit I: Energy demand and supply Indian and Global scenario of energy demand and supply statistics. Share of fossil fuels. Environmental concerns. Future of Fossil fuels. Alternative fuels. Energy prices. Drivers behind price development. Global price index	**6 Hours**
Unit II: Wind and Solar Energies Wind patterns, power generation systems, wind turbines, solar collectors, solar ponds. Combination of wind and solar energies. Case studies.	**6 Hours**
Unit III: Nuclear and Geothermal Energies Nuclear fission phenomenon, controlled fission, fast breed reactors, electricity generation. Geothermal resources, exploration techniques, environmental aspects, power plants, ocean geothermal system. Integration of nuclear and geothermal energies to minimize cost of electricity production.	**6 Hours**
Unit IV: Biomass and Hydrogen Energies Biomass production and utilization, biofuels, bioenergy, social, economic, and other issues related to biomass utilization. Technologies for production of hydrogen, biochemical hydrogen, hydrogen production from biomass, advantages of hydrogen as a fuel, hydrogen safety. Design of equipment.	**6 Hours**
Unit V: Energy storage Batteries, supercapacitors, fuel cell-based energy storage, hydrogen storage, pumped hydro, flywheel, cold energy storage.	**6 Hours**

Texts/ References:

1. Energy Efficiency and Renewable Energy Handbook, Editor D. Yogi Goswami and Frank Kreith, 2nd Edition, CRC Press, Taylor & Francis Group, 2016.
2. Introduction to Renewable Energy, Energy and the Environment Series, Vaughn Nelson, CRC Press, Taylor & Francis Group, 2011.
3. Energy Sources, Balasubramanion Viswanathan, Elsevier, 2016.
4. Alternative Energy Sources, E.E.Michaelides, Springer, 2012.

5. 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
6. Geo-Nuclear Energy Concept; Kibet Ronoh, GRC Transactions, Vol. 40, 2016, https://publications.mygeoenergynow.org/grc/1032417.pdf
7. Cao L, Yu IKM, Xiong X, et al (2020) Biorenewable hydrogen production through biomass gasification: A review and future prospects. Environ Res 186:109547. https://doi.org/https://doi.org/10.1016/j.envres.2020.109547.

8. Ferraz de Andrade Santos JA, de Jong P, Alves da Costa C, Torres EA (2020) Combining wind and solar energy sources: Potential for hybrid power generation in Brazil. Util Policy 67:101084. https://doi.org/https://doi.org/10.1016/j.jup.2020.101084

Co-Relationship Matrix

Indicate the relationships by1- Slight (low) 2- Moderate (Medium) 3-Substantial (high)

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	-	-	-	-	-	2	2	-	-	-	-	-	-	-
CO2	-	-	-	-	-	2	2	-	-	-	-	-	-	-
CO3	2	2	-	-	-	2	2	-	-	-	-	-	2	2
CO4	2	2	-	-	-	2	2	-	-	-	-	-	2	2
CO5	3	3	-	-	-	3	3	-	-	-	-	-	3	3
Avg	2.3	2.3	-	-	-	2.2	2.2	-	-	-	-	-	2.3	2.3

SEMESTER VI

CHCE3057	Process Dynamics, Instrumentations and Controls	L	T	P	C
		3	1	0	4
Pre-requisites/Exposure	Engineering Mathematics I and II, Physics				
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

Textbooks:

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

CHCE3059	Process Economics	L	T	P	C
		2	0	0	2
Pre-requisites/Exposure	Process Heat Transfer, Mass Transfer				
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 — 6 Hours

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 — 8 Hours

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. — 8 Hours

UNIT IV: COST ESTIMATION: Capital Investment, Time value of Money, Depreciation, Cost Elements, Unit Processing Cost, Estimation of Production cost and Revenues — 4 Hours

UNIT V: PROFITABILITY: Profitability and Margins, Profitability Criteria, P&L Account, Taxes & Insurance. — 4 Hours

Textbooks:

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

CHCE3058	Instrumentations and Controls Lab	L	T	P	C
		0	0	2	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	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2
CO1	3	-	-	-	-	-	-	-	-	-	-	-	-	-
CO2	-	-	-	3	-	-	-	-	-	-	-	-	2	-
CO3	-	-	-	-	-	-	-	-	-	2	-	-	-	3
CO4	-	-	-	-	-	-	-	3	3	-	-	3	-	-
Avg	3	-	-	3	-	-	-	3	3	2	-	3	2	3

CHCE3062	Particulate Technology	L	T	P	C
		2	0	0	2
Pre-requisites/Exposure	Momentum Transfer				
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 techniques of solid-fluid separation 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 and 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

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

CHCE3160	Particulate Technology 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 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

SLSG0205	Start your Startup	L	T	P	C
		2	0	0	2
Pre-requisites/Exposure					
Co-requisites					

Course Objectives:

The objectives of this course are:

- Foster an entrepreneurial mindset, including creativity, adaptability, and resilience and enable students to identify, and evaluate potential business opportunities!
- Develop skills in conducting market research and competitor analysis.
- Equip students with the tools to create comprehensive business plans and foster an understanding of the importance of effective team building and management.
- Provide insights into funding options and strategies for securing investment.
- Understand the challenges of scaling operations and developing sustainable growth strategies.
- **Course Outcomes**

CO1	**Foster** an entrepreneurial mindset, including creativity, adaptability, and resilience, and enable students to identify, evaluate potential business opportunities.
CO2	**Demonstrate** creativity by generating innovative business ideas.
CO3	**Identify and assess** potential business opportunities for viability and market fit.
CO4	**Develop** skills in conducting market research and competitor analysis.
CO5	**Conduct** thorough market research to gather relevant data and insights.
CO6	**Use** market research findings to make informed business decisions.
CO7	Equip students with the tools to **create** comprehensive business plans and foster an understanding of the importance of effective team building and management.
CO8	**Create** a well-structured and comprehensive business plan.

Course Description:

Course Curriculum: This course curriculum offers a comprehensive journey into the world of startups, covering fundamental aspects such as entrepreneurship basics, ideation, validation processes, business models, legal considerations, marketing strategies, and investor pitching. With a focus on practical application and real-world insights, it equips learners with the essential skills and knowledge necessary for navigating the dynamic landscape of entrepreneurship, fostering a holistic understanding of the startup ecosystem and its challenges.

Course Description:

1. **WEEK 1:** Introduction to the Startup world, Understanding the basics, Successful Entrepreneur's journey (can be done with alumni /seniors from Runway cohort) **2 hours**
2. **WEEK 2**: Definition and characteristics of an entrepreneur, motivation for starting a new startup, Exploring entrepreneurial ecosystem, entrepreneurial mindset and skills **2 hours**
3. **WEEK 3:** SWOT Analysis for an Entrepreneur, challenges and overcoming challenges in Entrepreneurship **2 hours**
4. **WEEK 4:** Startup Idea Scouting Techniques and Exercises, Successful startups and validation process **2 hours**

5. **WEEK 5:** Your target audience and validation process; Your target audience and validation process **2 hours**
6. **WEEK 6:** Lean Startup Methodology and MVP Development, product development and Prototyping **2 hours**
7. **WEEK 7**: Introduction to Business Model Canvas Framework, identifying key elements of startup business model. **2 hours**
8. **WEEK 8:** Value Proposition Canvas, How to create your VPC **2 hours**
9. **WEEK 9**: Legal considerations for startups, Intellectual Property Protection and Contracts **2 hours**
10. **WEEK 10:** Sales and marketing strategies for startups Digital marketing and customer acquisition **2 hours**
11. **WEEK 11:** Managing growth and avoiding common pitfalls, scalability, and Growth strategies **2 hours**
12. **WEEK 12:** Importance of storytelling, Storytelling **2 hours**
13. **WEEK 13:** Creating a compelling pitch deck, investor's perspectives on pitching to potential investors. **2 hours**
14. **WEEK14:** Social Impact and Sustainability in Entrepreneurship, entrepreneurship in emerging technologies and opportunities **2 hours**
15. **WEEK 15:** Review and recap key concepts and lessons learnt, final leg Q/A, Evaluation, guidance and hand-holding. **2 hours**

Text Books	**Entrepreneurship: The Practice and Mindset, Start Your Own Business**

Reference books	The Infinite Game by Simon Sinek The Lean Startup by Eric Ries The $100 Startup by Chris Gillebeau Start With Why by Simon Sinek Zero to One” by Peter Thiel

CO/PO Mapping for the course:

PO/CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2
CO1	3	3	2	-	-	-	-	-	-	-	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 VII

CHGS4014	Process Design and Intensification	L	T	P	C
		3	0	0	3
Pre-requisites/Exposure	Momentum Transfer, Process Heat Transfer, Mass Transfer, Chemical Reaction Engineering				
Co-requisites					

A. Course Objectives

This course will enable the students:

1. To provide an understanding of the concept of Process Intensification (PI).
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 Interpret the operating principles of several intensified technologies.

CO4 Analyse the range of potential applications of intensified equipment.

C. Course curriculum

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. — 3 Hours

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 — 6 Hours

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. — 7 Hours

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 — 8 Hours 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. 6 Hours

Textbooks:

1. Stankiewicz, A. and Moulijn, (Eds.), Reengineering the Chemical Process Plants, Process Intensification, Marcel Dekker, 2003.

2. Reay D., Ramshaw C., Harvey A., Process Intensification, Butterworth Heinemann, 2008.

3. Kamelia Boodhoo (Editor), Adam Harvey (Editor), Process Intensification Technologies for Green Chemistry: Engineering Solutions for Sustainable Chemical Processing, Wiley, 2013

Reference Book

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

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

CHCE4132	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

HSFS4033	Process Safety	L	T	P	C
		3	0	0	3
Pre-requisites/Exposure					
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 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: Introduction- Environmental Concern and Safety, Accidental statistical methods, significant industrial hazards of history. **9 Hours**

Unit II: Fires and Explosions, Design to Prevent Fires and Explosions, Fire extinguishers, fire alarm systems, **12 Hours**

Unit III: Introduction Source Models, Laws and Regulations, Toxicology, Toxic Release, and dispersion Models, **12 Hours**

Unit IV: Personnel Protective Equipment (PPE), Introduction to Reliefs and Relief Sizing **12 Hours**

Textbooks

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	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO 11	PO12	PSO 1	PSO 2
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

SEMESTER VIII

CHCE4035	**Carbon Technologies And Policies**	L	T	P	C
Version 1.0		3	0	0	3
Pre-requisites/Exposure					
Co-requisites					

Course Description

This course will focus on the intricate interplay between "Carbon Technologies and Policies." Delve into the science of carbon neutrality, global warming, and emission quantification. Explore diverse carbon capture methods, from biorefineries to utilization processes, evaluating their environmental implications. Investigate carbon storage approaches, including geological storage and innovative biological solutions. Delve into the global carbon industry, assessing storage capacities, waste management, and climate modeling. Finally, navigate the complex landscape of carbon policies and legislation, dissecting governmental initiatives and legal frameworks while strategizing effective implementation for a sustainable future.

Course Objectives

1. Understanding of carbon-related concepts, encompassing carbon neutrality, radiative forcing, and carbon inventory techniques.

2. Apply acquired knowledge to evaluate and compare natural and synthetic carbon capture systems, discerning their feasibility and effectiveness.

3. Analyze the carbon flux across various sectors, including industries, energy production, and transportation, to identify potential points for emission reduction and carbon neutral electricity generation.

Course outcomes:

CO1: Understanding carbon neutrality, radiative impacts, and budgeting principles.

CO2: Assess environmental implications of diverse carbon capture technologies.

CO3 : Evaluate efficiency and limits of varied carbon storage methods.

CO4: Evaluating legal-political dimensions, linking actions, protection, and sustainability.

Unit I., Introduction to carbon neutrality: Global warming; Radiative forcing; Carbon - mineralization, inventory, budgeting, and allocation; Carbon emissions, Carbon capture systems -Natural and Synthetic, Carbon neutrality, Emission standards, technologies for emission abatement, Environmental implications,	**8 hours**
Unit II. Carbon Flux and Use: Economy concerns: Global carbon stocks, Biomass as carbon sinks, Carbon in industrial effluents, carbon transport processes in land, water, and air; Heavy Industries and Manufacturing; Decarbonizing Global Energy; Hydrogen as Carbon free Energy alternative, Carbon neutral electricity generation.	**8 hours**
Unit III. Carbon capture: Biorefineries and utilization: Thermo-chemical processes, Combustion, Pyrolysis, Hydrothermal processes- Hydrothermal	**9 hours**

Carbonization, Hydro-thermal Liquefaction, Gasification; Emissions and Fate; Post-Combustion Capture, Capture by Oxyfuel Combustion, Pre-Combustion Capture, Carbon Dioxide Utilization, Carbon Negative Technologies

Unit IV. Carbon Storage and Applications: Transport of Carbon Dioxide; Geological Storage, Rocks for Geological Carbon Storage, Reservoirs, Seals and Traps, Storage in Aquifers and Depleted Oil Fields, Trapping the Carbon Dioxide, Leakage and Monitoring, Modern C capture Technologies – Microorganisms and Biomass; Global Storage Capacity, CO_2 Pollution and Waste Disposal, Carbon as Global Industry, Net-zero projections, and Climate models. **10 hours**

Unit V. Carbon Neutrality Implementation: Policies and Legislation Various government initiatives for Carbon abatement and Carbon neutral Technology development; Legal and political aspects in Carbon management, Carbon management policies, plan, and programs i.e., Forest Rights Act, Biodiversity Act, The Land, Water and Air Act, Legal Policy instruments in Carbon emission Management: National Forest Policy of 1988, National Environment Policy of 2004, National Energy Policy (NEP), National Action Plan on Climate Change of 2008, Forest Protection Act of 1980, Environment Protection Act of 1986, ICZM-Indian Coastal zone management, Water Act, 1981, Forest Rights Act of 2006. Green Tribunal Act, 2009; Strategies on Policy implementation. **10 hours**

Textbooks:

1. Carbon Capture and Storage: Efficient Legal Policies for Risk Governance and Compensation" by Dr. Marius-Christian Frunza
2. Carbon Capture and Storage: Emerging Legal and Regulatory Issues" by Richard Macrory and Yinka Somorin

Reference Book:
Carbon Management, Technologies, and Trends in Mediterranean Ecosystems" edited by Antonella Petrillo and Giuseppe Corti

Co-relationship matrix

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

CHCE4034	Advance Transport Phenomena	L	T	P	C
		3	1	0	4
Pre-requisites/Exposure	Mass Transfer; Heat Transfer; Momentum Transfer;				
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 equipment 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

Textbooks:

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

SPECIALIZATIONS

Energy Systems and Storage

EPEG3040P	Renewable Energy Technologies	L	T	P	C
Version 4.0		**3**	**0**	**0**	**3**
Pre-requisites/Exposure					
Co-requisites					

Course Objectives

Understand the importance and global significance of renewable energy as a sustainable and clean energy source.

1. Identify and differentiate between various types of renewable energy technologies, including solar, wind, hydroelectric, biomass, geothermal, and tidal energy.
2. Comprehend the principles of energy conversion for different renewable energy sources, including the photovoltaic effect, wind turbine operation, hydroelectric power generation, biomass combustion, geothermal heat extraction, and tidal power generation.
3. Analyze the environmental and economic benefits of renewable energy, including the reduction of greenhouse gas emissions, energy security, job creation, and cost-effectiveness.
4. Familiarize students with the policy and regulatory frameworks governing renewable energy, both at the national and international levels, and understand the impact of incentives and regulations on renewable energy development.
5. Develop a thorough understanding of specific renewable energy technologies, including solar energy systems, wind energy systems, hydropower generation, biomass energy systems, geothermal power generation, and emerging technologies.
6. Gain practical knowledge of the design, integration, and operation of renewable energy systems, including grid-tied solar photovoltaic systems, wind farms, hydroelectric plants, and biomass facilities.
7. Evaluate the environmental considerations and sustainability aspects related to renewable energy technologies, including impact assessments, ecological implications, and the role of renewable energy in mitigating climate change.

Course Outcomes

On the completion of this course, the student will be able to:

CO1	Define and explain the working principle of technologies to harvest energy from various renewable energy sources
CO2	Identify and compare different renewable energy technologies based on their energy conversion processes.

CO3	Propose and examine the integrated renewable energy systems based on specific project requirements and site characteristics.
CO4	Analyze and present the solution of problems related to grid integration challenges *w.r.t.* renewable energy systems.

Catalog Description

Renewable energy has emerged as a vital solution to address the challenges of climate change and the increasing demand for sustainable and clean energy sources. This course on Renewable Energy Technologies provides a comprehensive understanding of various renewable energy sources and their applications. The course has been design to equip students with the knowledge and skills required to contribute to the development, implementation, and management of renewable energy projects. The course starts with an introduction to renewable energy, highlighting its significance, types, and global energy scenario. Students are able to learn the principles of energy conversion for solar, wind, hydroelectric, biomass, geothermal, and tidal energy. They explore the environmental and economic benefits of renewable energy and gain insights into the policy and regulatory frameworks that shape the renewable energy industry. In the solar energy unit, the students learn about solar radiation, photovoltaic systems, solar thermal technologies, and their integration into the grid. They can explore the wide range of applications for solar energy, including residential, commercial, and industrial installations. The wind energy unit focuses on wind characteristics, wind turbine technology, wind farm design, grid integration challenges, and energy storage solutions. Students gain a deep understanding of onshore and offshore wind energy systems and explore emerging trends in the wind energy sector. The topics on hydroelectric and biomass energy technologies are covered in the subsequent unit, which examines hydropower generation, tidal and wave energy technologies, biomass feedstocks, combustion, gasification, and biofuel production. The course further explores geothermal energy, including geothermal heat sources, power generation techniques, and enhanced geothermal systems (EGS). Throughout the course, students engage in practical exercises, case studies, and discussions to apply their knowledge and develop critical thinking skills. By the end of the course, students will be equipped with a comprehensive understanding of renewable energy technologies, their applications, and the environmental and economic implications. They will be prepared to contribute to the transition towards a sustainable and renewable energy future.

Course Content

Unit I: Introduction to Renewable Energy **8 Hours**

Overview of renewable energy, definition, importance, and global energy scenario, how are they different from other energy sources, types of renewable energy (solar, wind, hydroelectric, biomass, geothermal, and tidal energy), basic energy conversion principles (photovoltaic effect, wind turbine operation, hydroelectric power generation, biofuel production, geothermal heat extraction, and tidal power generation), environmental and economic benefits (reduction of greenhouse gas emissions, energy security, job creation, and cost-effectiveness), policy and regulatory frameworks (national and international initiatives promoting renewable energy, feed-in tariffs, renewable portfolio standards, and carbon pricing).

Unit II: Solar Energy Technologies **8 Hours**

Solar Radiation (Sun's energy, solar radiation measurement, and solar resource assessment), Solar Photovoltaic (PV) Systems (Basic principles, PV module technologies, system components, and design considerations), Solar Thermal Systems (Solar water heating, solar space heating, and concentrated solar power (CSP) technologies), Integration and Grid Connection (Grid-tied PV systems, net metering, and integration challenges), Solar Energy Applications (Residential, commercial, and industrial-scale solar installations).

Unit III: Wind Energy Technologies **9 Hours**

Wind Energy Fundamentals (wind characteristics, wind speed measurement, and wind resource assessment), Wind turbine technology (horizontal-axis and vertical-axis wind turbines, components, and operating principles), Wind farm design and layout (site selection, turbine placement, wake effects, and optimization techniques), Grid integration and energy storage (Challenges and solutions for integrating wind power into the grid, energy storage systems for wind energy), Wind Energy Applications (onshore and offshore wind farms, community wind projects, and wind-diesel hybrid systems).

Unit IV: Hydroelectric and Biomass Energy Technologies **10 Hours**

Hydropower Generation (Types of hydropower plants, dam design and operation, run-of-river systems, and pumped storage), Tidal and Wave Energy (Tidal barrage and tidal stream technologies, wave energy converters, and marine energy resource assessment), Biomass Energy (Biomass feedstocks, combustion, gasification, anaerobic digestion, and biofuels production), Biogas and Bioenergy Systems (Biogas production from organic waste, biogas utilization, and bioenergy in transportation), Environmental considerations (Impact assessment, ecological implications, and sustainability of hydroelectric and biomass energy).

Unit V: Geothermal Energy and Emerging Technologies **10 Hours**

Geothermal Energy (Geothermal heat sources, geothermal gradient, and subsurface exploration techniques), Geothermal Power Generation (Dry steam, flash steam, and binary cycle power plants), Enhanced Geothermal Systems (Geothermal reservoir engineering, hydraulic fracturing, and heat exchange mechanisms), Ocean Energy (Ocean thermal energy conversion (OTEC), tidal energy, and salinity gradient power),

Other emerging renewable technologies (advanced solar technologies, concentrated solar power, solar fuel production, hydrogen fuel cells, and energy storage innovations.

Text Books

4. Renewable Energy: Power for Sustainable Future. (2018). Kiribati: Oxford University Press.
5. Nelson, V. (2011). Introduction to Renewable Energy. United Kingdom: CRC Press.
6. Kalogirou, S. A. (2013). Solar Energy Engineering: Processes and Systems. Germany: Elsevier Science.
7. Rogers, A. L., Manwell, J. F., McGowan, J. G. (2010). Wind Energy Explained: Theory, Design and Application. Germany: Wiley.
8. Klass, D. L. (1998). Biomass for Renewable Energy, Fuels, and Chemicals. United States: Elsevier Science.
9. Glassley, W. E. (2011). Geothermal Energy: Renewable Energy and the Environment. United States: CRC Press.

Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination

Examination Scheme:

Components	Internal Assessment	MSE	ESE
Weightage (%)	50	20	30

Co-Relationship Matrix

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	2	2	2	-	-	-	-	-	-	-	-	1	1	3
CO2	3	3	2	2	-	-	-	-	-	-	-	-	1	1	3
CO3	3	3	3	3	-	-	-	-	-	-	-	-	1	2	3
CO4	3	3	3	3	-	-	-	-	-	-	-	-	1	2	3
Avg	3	2.8	2.5	3	-	-	-	-	-	-	-	-	1	1.5	3

EPEG3051P	Energy Policies	L	T	P	C
Version 4.0		3	0	0	3
Pre-requisites/Exposure					
Co-requisites					

Course Objectives

1. Understand the importance and significance of energy policies: Students will grasp the fundamental role that energy policies play in addressing global energy challenges, promoting sustainable development, and transitioning to a low-carbon economy.
2. Comprehend energy policy frameworks and instruments: Students will gain knowledge of different energy policy frameworks, regulatory mechanisms, and market-based instruments used to achieve energy policy goals. They will explore renewable energy support schemes, energy efficiency policies, and standards to understand the diverse policy tools available.
3. Develop analytical skills for energy policy evaluation: Students will learn methodologies and tools for analyzing and evaluating energy policies. They will assess the impacts of policies on energy markets, the environment, and society, and acquire skills in conducting cost-benefit analysis and economic evaluation of energy policies.
4. Explore the intersection of energy policies and sustainable development: Students will understand the interconnectedness between energy policies and sustainable development goals. They will explore the promotion of energy access, poverty alleviation, and energy justice in policy design and implementation.
5. Engage with emerging trends and future directions in energy policies: Students will stay abreast of the latest developments and trends in energy policies. They will explore energy transition strategies, digitalization, smart energy policies, and the integration of renewable energy sources, equipping them to contribute to future energy policy discussions and developments.

Course Outcomes

On the completion of this course, the student will be able to:

CO1	Define the terms and explain the energy policy frameworks and policy instruments
CO2	Identify the various stakeholders involved in energy policy formulation and summarize the impacts of energy policies on current energy market
CO3	Apply the understanding of energy policies and evaluating the effectiveness of specific policies
CO4	Analyze and present energy policies by examining their strengths, weaknesses, and impacts through comprehensive evaluations of case studies and policy analysis reports.

Catalog Description

The Energy Policies course is designed to provide students with a comprehensive understanding of the principles, frameworks, and implementation strategies related to energy policies. The course explores the critical role of energy policies in addressing global energy challenges, promoting sustainable development, and transitioning to a low-carbon economy. In this course, students will delve into the historical context and evolution of energy policies, examining their objectives and the diverse stakeholders involved. They will gain insights into various energy policy frameworks, including national, regional, and international approaches, and explore the regulatory mechanisms and market-based instruments employed to achieve policy goals. The course will also cover renewable energy support schemes, energy efficiency policies, and standards, enabling students to comprehend the diverse policy instruments used to promote sustainable energy systems. Students will learn how to analyze and evaluate energy policies, examining their impacts on energy markets, the environment, and society. They will study methodologies and tools for policy analysis, conduct cost-benefit assessments, and explore monitoring and evaluation mechanisms to measure policy effectiveness. Moreover, the course will delve into the interconnectedness between energy policies and sustainable development goals, emphasizing the promotion of energy access, poverty alleviation, and energy justice. Students will explore emerging trends and future directions in energy policies, including energy transition strategies, digitalization, smart energy policies, and the integration of renewable energy sources. Through case studies, discussions, and practical exercises, students will develop a critical understanding of energy policies and gain the skills needed to analyze, evaluate, and contribute to the design of effective energy policies. By the end of the course, students will be equipped with the knowledge and tools to navigate the complex landscape of energy policies and contribute to sustainable energy transitions.

Course Content

Unit 1: Introduction to Energy Policies

Overview of energy policies and their significance, Historical context and evolution of energy policies, Key stakeholders and their roles in energy policy development, Energy policy goals and objectives (e.g., sustainability, security, affordability), Case studies highlighting successful energy policies

Unit 2: Energy Policy Frameworks and Instruments

Different types of energy policy frameworks (e.g., national, regional, international) Regulatory mechanisms and market-based instruments (e.g., carbon pricing, feed-in tariffs) Renewable energy support schemes and incentives Energy efficiency policies and standards Case studies on the implementation and effectiveness of policy instruments

Unit 3: Energy Policy Analysis and Evaluation

Methods and tools for energy policy analysis, Assessing policy impacts on energy markets, environment, and society, Cost-benefit analysis and economic evaluation of energy policies Policy monitoring, evaluation, and feedback mechanisms, Case studies on evaluating energy policy effectiveness and lessons learned

Unit 4: Energy Policy and Sustainable Development

Linkages between energy policies and sustainable development goals Energy access and poverty alleviation policies Decentralized energy systems and community-based approaches Energy justice and equity considerations in policy design Case studies on energy policies promoting sustainable development

Unit 5: Emerging Trends and Future Directions in Energy Policies

Energy transition policies and strategies, Integration of renewable energy and grid modernization, Digitalization and smart energy policies, Energy storage and electrification policies, Policy responses to emerging technologies (e.g., hydrogen, carbon capture)
Case studies on innovative energy policies and future outlook

Text Books

1. Bhaskar, B. (2013). Energy Security and Economic Development in India: A Holistic Approach. India: Energy and Resources Institute.

2. Ibp, I. (2016). India Energy Policy, Laws and Regulations Handbook Volume 1 Strategic Information and Basic Laws. United States: International Business Publications, USA.
3. Dwivedi, R. M. (2011). Energy Sources and Policies in India. India: New Century Publications.
4. Naseem, M., Naseem, S. (2017). Energy Law in India. Netherlands: Wolters Kluwer.

Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination
Examination Scheme:

Components	Internal Assessment	MSE	ESE
Weightage (%)	50	20	30

Co-Relationship Matrix

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO3
CO1	1	1	-	-	-	-	2	2	-	-	-	-	-	-	3
CO2	1	1	-	-	-	-	2	2	-	-	-	-	-	-	3
CO3	1	1	-	-	-	-	2	2	-	-	-	-	-	-	3
CO4	1	1	-	-	-	-	2	2	-	-	-	-	-	-	3
Avg	1	1	-	-	-	-	2	2	-	-	-	-	-	-	3

EPEG3052P	**Energy Storage Systems**	L	T	P	C
Version		3	0	0	3
Pre-requisites/Exposure					
Co-requisites					

Course Objectives

1. Demonstrate the need and essence of Energy Storage
2. Understand the various Energy Storage Technologies
3. Simulate and Design the Energy Storage Technologies.
4. Apply and Design Energy Storage Based System

Course Outcomes:

After completion of course students will be able to

CO1	Understand the need and application of Energy Storage
CO2	Analyze the advanced trends in Energy storage systems.
CO3	Analyze and estimate the performance of an energy storage system.
CO4	Apply and design the Energy storage system for specific application(s)

With the versatility and variable use of energy, the Energy storage can help in stabilizing the grid. Energy storage in various forms can bring down the peak demand in control. With present growth of Renewable Energy, the Energy storage technology can be a game change in the field of power engineering.

Unit I:

5 Hours

Energy Storage Fundamentals Energy storage & Energy Balance. Load curves and need of Energy Storage. Uncertainty of natural Energy sources like solar, wind & Rain. Real life examples of Energy storage system. Types of energy storage mechanism include Thermal Energy Storage, Compressed air energy Storage, Fly Wheels, Electrical Energy, Pumped Energy Storage, Hydrogen, and other chemical energy storage (Electrolysis Process). Applications and benefits of Energy Storage. Energy Storage economics

Unit II: Mechanical Energy Storage System Thermal Energy Storage: Thermodynamics laws, Heat Transfer, Heating & Cooling, active & Passive. Conventional Thermal Energy storage materials like ferrous materials. Advanced thermal Energy Storage material, Phase Change Material. Various PCT and their properties. Case studies of PCM based systems. Challenges and limitations of PCM.

10 **Hours**

ii. Mechanical Energy Storage System: Pneumatic & Compressed energy, Spring dynamics, applications of spring. Compresses air Energy Storage system, Analysis of compressed air energy storage, limitations, and challenges. Applications of CAES. Flywheels, Flywheel, Moment of Inertia, Analysis of Flywheel Energy. Applications and Challenges.

iii. Pumped storage System: Architecture of Pumped Energy Storage System, Analysis, and energy estimation of pumped storage power plant.

iv. Gravity Energy Storage System: Concept, Planning and Design of Gravity Energy Storage Systems.

Unit III Electrical Energy Storage

15 Hours

Primary Cells: Cell history, Chemistry of primary cells, Dry cells, Challenges and Applications

ii. Secondary Cells: Thermodynamic Voltage, Gibbs free energy, Chemistry of Secondary Cells, Specific Energy & power, Open Circuit & cut off voltage, Battery Internal Resistance, State of Charge (SoC), Self-Discharge. Constant Voltage and constant current charging. Lead Acid Batteries, Ni-Cd batteries etc. Challenges & Limitation
iii. Lithium-ion batteries: Chemistry of Li-Ion batteries, Thermodynamic voltage. Construction & working. Li-Ion battery materials Electrodes, Electrolyte, Current collecting electrode, Binder, separator, etc. Steps in Li-Ion battery manufacturing process. Advantages and application of Li-Ion batteries.
iv. Advances in EES: Performance enhancement of Li-ion batteries, various materials used in performance improvement, Solid State Batteries, aluminum-ion batteries, Sodium Ion batteries, Ultra Capacitors, Super Conducting Energy Storage System, fuel cells etc.

Unit IV: Energy Storage Management System **10 Hours**

Battery Banks performance, arrangements of Cells, Behaviors or cells, Internal Resistance and cell characteristics, Cell operating region, State of Charge, State of Health, State of function. Battery Management System Architecture, Sensor circuit, Charge equalizers; Battery Energy management algorithm, eV battery Energy management system, V2G technology; Battery Thermal Management System: Cooling of Batteries, use of PCM in battery Thermal management.

Unit V Safety in Energy Storage handling Systems **5 Hours**

Safety need and aspect, Energy release mechanism, Lock Out- Tag Out (LOTO) protocols.

Reference Book:

i. Handbook on Battery Energy Storage System, Asian Development Bank-2018.
ii. Battery Management System Vol. II – Georgery Pitt
iii. Recent Research trends in Energy Storage – Springer.
iv. Web material and research papers and articles.

Table: Correlation of POs and PSOs v/s COs

PO/CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PSO 1	PSO 2	PSO 3
CO1	2	2	2	-	-	-	-	-	-	-	-	-	-	2
CO2	-	-		2	-	-	-	-	-	-	-	-	-	2
CO3	-	2	-	-	3	-	1	-	-	-	-	-	-	2
CO4	-	-	3	-	3	-	3	-	-	-	-	-	-	2
Avg	2	2	2.5	2	3	-	2	-	-	-	-	-	-	2

1= weakly mapped 2 = moderately mapped 3 = strongly mapped

EPEG4045P	Waste to Energy	L	T	P	C
		3	0	0	3
Pre-requisites/Exposure					
Co-requisites					

Course Objectives:

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

Course Outcomes:

CO1	Apply Techno-economic feasibility of available technologies for Waste to Energy generation
CO2	Apply the knowledge in planning and operations of Waste to Energy plants
CO3	Analyse the various aspects of Waste to Energy Management Systems
CO4	Evaluate the regulatory policies of green fuels and biomass gasification technologies

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 Hours)

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 Hours)

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

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

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 (7Hours)

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 Hours)

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: (**7Hours**)

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.

Textbooks:

1. *Waste* Management: Research Advances to Convert Waste to Wealth by A.K HaGHI, Nova Science Publishers, Inc
2. Biomass to Energy Conversion Technologies: The Road to Commercialization by Pratima Bajpai, Elsevier Publisher.
3. Waste to Energy Conversion Technology by Naomi B Klinghoffer, Marco J Castaldi, Elsevier, 2013, ISBN: 0857096362, 9780857096364
4. 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	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	2	2	2	-	-	1	-	-	-	-	-	-	-	2
CO2	2	2		3	-	-	2	-	-	-	-	-	-	-	2
CO3	3	3	2	2	-	-	2	-	-	-	-	-	-	-	2
CO4	3	3	2	2	-	-	2	-	-	-	-	-	-	-	2
Avg.	2	2	2	2-	-	-	2	-	-	-	-	-	-	-	2

CHCE4027P	Hydrogen Energy	L	T	P	C
		3	0	0	3
Pre-requisites/Exposure					
Co-requisites					

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	Understand the process of hydrogen generation, storage, and transportation
CO2	Apply the techniques for hydrogen production, storage, and transportation
CO3	Apply the codes and standards for hydrogen energy
CO4	Analyze the major issues and challenges in hydrogen pipeline transport and storage

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 Hours)

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

Unit-2 Hydrogen production (10 Hours)

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 Hoursrs)

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 Hours)

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

Textbooks:

1. *Hydrogen Production*, 2017. 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.
2. *Hydrogen Fuel-Production*, 2009.Transport, and Storage. Editor Ram B. Gupta. CRC Press Taylor & Francis Group.

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, 2^{nd} edition, 2015.
4. . Fuel cell fundamentals by Ryan O'HAYRE, and SUK-WON CHA, Wiley Publisher, 3^{rd} edition (2016) ISBN- 978111911420

CO/PO Mapping for the course:

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	-	-	-	-	-	-	---	-	-	--	-	-	-	-
CO2	3	3	-	-	-	-	-	-	-	-	-	-	--	-	1
CO3	3	3	-	-	-	-	-	-	-	-	-	-	-	-	-
CO4	3	3	-	-	-	-	-	-	-	-	-	-	-	-	2
CO5	-	-	-	-	-	3	3	-	-	-	-	-	-	-	-
Avg.	3	3	-	-	-	3	3	-	-	-	-	-	-	-	2

Gas Engineering Informatics

		L	T	P	C
CHGS3022P	**Natural Gas Processing**	L	T	P	C
Version 1.0		3	0	0	3
Pre-requisites/Exposure	Natural Gas Engineering				
Co-requisites					

COURSE OBJECTIVES:

1. Help students to understand the importance of processing Natural Gas
2. Enable students to identify different processing facilities such as separation of oil and gas, dehydration, and sweetening processes.
3. Enable students to acquire knowledge of NGL recovery methods.

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

CO1	Understand the process of natural gas processing.
CO2	Apply the principles of natural gas engineering to natural gas processing
CO3	Analyze the relative merits/demerits of different processing methods
CO4	Design the natural gas processing systems

CATALOG DESCRIPTION:
Natural processing is an important sector in natural gas industry. Raw natural gas contains impurities like water vapor, carbon di oxide, hydrogen sulphide, mercury which reduces calorific value and detrimental to pipeline and other processing equipment. Components like hydrogen sulphide and carbon di oxide are toxic and hazardous. In this course, the focus will be on improving technical aspects of natural gas processing. Students will learn how to design glycol dehydration and sweetening processes. 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. Class participation is a fundamental aspect of this course. Students will be encouraged to actively take part in all group activities and to give an oral group presentation. Students will be expected to interact with media resources, such as, web sites, videos, DVDs, and newspapers.

COURSE CONTENT:
Unit 1: GAS DEHYDRATION **18 Hours**
Absorption dehydration – Glycol dehydration system, System Parameters, Contactor Sizing and Stage Calculations, Graphical and Analytical Methods, Regeneration. Adsorption dehydration, Types of solid desiccants - Alumina, Gels, Molecular sieves, System Parameters, Operation and design, regeneration.

Unit 2: GAS SWEETENING **17 Hours**

Acid Gases Toxicity, Solid Bed Process, Absorbent Selection, Selection Variables and Design, Physical & Chemical absorption Processes – Water wash process, Selexol process, Alkanol-amine process, carbonate process. Sulphur Recovery - Holmes-Stretford process, Claus process.

Unit 3: NATURAL GAS LIQUIDS **10 Hours**

Methods to control the dew points and recovery of LPG, Propane and Ethane recovery from Natural Gas, Stabilization of the NGL.

TEXT BOOK

1. John M Campbell (Sep. 92) "Gas Conditioning & Processing" Volume 2, Volume 3, Volume 4 published by Campbell Petroleum Series

REFERRENCE BOOKS:

1. Rojey A. & Jaffret C., "Natural Gas-Production, Processing, Transport", Editions Technip-Paris, 1997.
2. G. G. Nasr & N. E. Connor, "Natural Gas Engineering and Safety Challenges", Springer, 2014.
3. Dr. Boyun Guo and Dr. Ali Ghalambor, 2005 'Natural Gas Engineering Handbook', Gulf Publishing Company.
4. Arthur Kohl & Richard Neilson (Aug 97) "Gas Purification" Gulf Professional publishing.

MODES OF EVALUATION: Quiz/Assignment/ presentation/ extempore/ Written Examination

EXAMINATION SCHEME:

Components	**Internal Assessment**	**MSE**	**ESE**
Weightage (%)	**50**	**20**	**30**

RELATIONSHIP BETWEEN THE COURSE OUTCOMES (COS) AND PROGRAM OUTCOMES (POS):

PO/ CO	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PS O1**	**PS O2**	**PS O3**
CO1	3	3	3	-	-	-	-	-	-	-	-	-	3	2	1
CO2	3	3	3	-	-	-	-	-	-	-	-	-	3	2	1
CO3	3	3	3	-	-	-	-	-	-	-	-	-	3	2	1
CO4	3	3	3	-	-	-	-	-	-	-	-	-	3	2	1
Avg.	**3**	**3**	**3**	-	-	-	-	-	-	-	-	-	**3**	**2**	**1**

1=weakly mapped 2= moderately mapped 3=strongly mapped

CHGS 3007P	Pipeline Transportation of Oil & Gas	L	T	P	C
Version 1.0		3	0	0	3
Pre-requisites/Exposure					
Co-requisites					

Course Objectives

1) Students aim in developing skills on pipeline design, operation, construction and maintenance.
2) The student has the opportunity to analyze and interpret data, to identify, formulate, and solve pipeline-engineering problems.

Course Outcomes

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

CO1	Apply the knowledge of Mathematics, Science, and Engineering in property calculations
CO2	Analyse the Pressure Drop in Oil and Gas Pipelines.
CO3	Analyse the various techniques used in pipeline laying and construction.
CO4	Analyze Pipeline issues and mitigation measures.

Catalog Description:

The subject covers onshore pipeline engineering activities that students will find useful while working in pipeline industry. The syllabus focuses on key areas like pipeline design, operation, construction and maintenance. The students also go through the pipeline codes such as ASME B31.4, ASME B31.8. The syllabus is divided into a number of sections including design, construction, pressure testing, operation and maintenance, condition monitoring, decommissioning and pipeline industry developments.

Course Content

Unit I: A. Basics of Pipeline Operations **6Hours**

Modes of Transporting Oil & Gas, Importance of Pipelines, Pipeline Systems, Design Life of Pipelines, Size and Cost of Pipelines, History of Pipelines in India, Major Codes and Standards in Pipeline, NPS Chart

B. Properties of Gas and Liquid **8 Hours**

Various Systems, Standard Conditions, Gases: Volume/Specific Gravity/Viscosity/Average Molecular Weight Compressibility Factor/Average Pressure Calculation/Heating Value, Liquids: Mass/Volume/Specific Weight/API Gravity(Dependency on Temperature)/Specific Gravity of Blended Liquids/Viscosities of Liquid Mixtures(Variation with Temperature)/Bulk Modulus/Vapor Pressure

Unit II:

Pressure Drop Calculations: **10 Hours**

A. For Gases:

Gas: Flow Equations, Generalized Flow Equation, Weymouth Equation, Panhandle A equation, Panhandle B Equation, Transmission Factor Effect of Pipeline Elevation (Single Slope, Multiple Slope), Velocity of Gas in Pipeline, Erosional Velocity, Reynolds Number (gas pipeline), Friction Factor Calculations.

B. For Liquids:

Converting Pressure to Head, Velocity of Liquid in Pipelines, Pressure Drop Equations (Hagen Williams Equation, Shell MIT Equation, Miller Equation), Looping and Branching in Pipeline (Gas and Liquid)

Unit III:

Pipeline Construction and Laying Activities **6 Hours**

Pipeline Construction, Pipe Laying, Pipe Specifications, Route Surveying,
Trenching, Welding, Wrapping, Pig launchers and receivers, Roads and River Crossings

Unit IV: Pumps and Compressors **8 Hours**

Types of Pumps (Reciprocating and Centrifugal Pumps), Pumps and Compressor Characteristics Curves, Single and Multistage pumps and compressors, Efficiency Calculations, Congealing

Unit V: Pipeline Issues and Mitigation Measures **7 Hours**

Wax, Scaling, Condensate, Corrosion, Thermal Variations in Pipeline, Automation and SCADA Pipeline Leakage, Corrosion and Cathodic Protection, Case Study.

Text Books

1) Menon, E. S. (2005). Gas pipeline hydraulics, CRC Press, Taylor and Francis Group, Boca Raton, FL.
2) Menon, E. S. (2005). Liquid pipeline hydraulics, CRC Press, Taylor and Francis Group, Boca Raton, FL
3) E.W. McAllister (2002). Pipeline Rules of Thumb Handbook, Gulf Professional Publishing

Reference Books

1) Duraid, A. (2010**).** A Quick Guide to Pipeline Engineering, Wood hand Publishing, Cambridge, England.
2) Arnold, K. (1989). Surface Production Operations. Gulf Publishing Company, Houston, Texas.
3) Piping and Pipeline Engineering: Design, Construction, Maintenance, Integrity and Repair; George A. Antaki, Marcel Dekker Inc.,2003
4) Menon, E. S. (2005). Gas pipeline hydraulics, CRC Press, Taylor and Francis Group, Boca Raton, FL

Modes of Evaluation: Quiz/Assignment/ Class Test/ Tutorial

Examination Scheme:

Components	**Internal Assessment**	**MSE**	**ESE**
Weightage (%)	50	20	30

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

PO/ CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3
CO1	3	3	1	2	-	-	-	-	-	-	-	-	1	1	-
CO2	3	3	1	2	-	-	-	-	-	-	-	-	1	1	-
CO3	2	3	2	3	-	-	-	-	-	-	-	-	1	1	-
CO4	3	2	1	2	-	-	-	-	-	-	-	-	1	1	-
Avg	3	3	1	2	-	-	-	-	-	-	-	-	1	1	-

1=weakly mapped 2= moderately mapped 3=strongly mapped

CHGS3033P	LNG & Storage of Natural Gas	L	T	P	C
Version 1.0		3	0	0	3
Pre-requisites/Exposure	**Natural Gas Engineering, Natural Gas Processing**				
Co-requisites	--				

Course Objectives

- To help students identify the major components of liquefied natural gas (LNG) liquefaction plant.
- To enable students, analyze the constructional features of LNG storage tanks and carriers.
- To make students identify the features of the LNG receiving terminal
- To enable students understand design vaporizers used in LNG regasification.
- To make students aware of storage of natural gas.

Course Outcomes

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

CO1	Understand the process of LNG production, storage and transportation
CO2	Apply the principles to develop the technologies for LNG production, storage and transportation
CO3	Analyze the problems arising in the process of LNG production, storage and transportation
CO4	Design equipments for LNG production, storage and transportation

Catalog Description

This subject covers LNG liquefaction technologies being used worldwide along with related fundamentals of thermodynamics. It also covers features of LNG storage tanks being used for its transportation and storage. Regasification of LNG with respect to facilities required and operational details are also covered. Natural gas storage types have been covered at the end.

Course Content

Unit I-Liquefaction Train (10 Hours)

Introduction, drivers, safety, properties & health hazards, industry standards & regulatory compliance for LNG safety. LNG value chain, Liquefaction Systems - Feed gas preparation technology. LNG plant capacity & commercial technologies. Advantages & Limitations of technologies, Selection of appropriate technology, Major components of LNG liquefaction plant. Design and Operational characteristic of Liquefaction Train. Thermodynamics of Gas Liquefaction & Heat Transfer Process.

Unit II-LNG Storage & Transportation (8 Hours)

LNG storage tanks. Single containment tanks. Double containment tanks. Storage volume, LNG Tankers. LNG Tankers.

Unit III-LNG Receiving Terminals & Trade (8 Hours)

Port Facilities. LNG Terminals. SPA features, shipping terms. Sourcing and Economics. Sales & purchase agreement, LNG Trade.

Unit IV-LNG Regasification & Cold Utilization (9 Hours)

Processes for LNG Regasification. Processes for LNG Regasification. LNG Cold Utilization. Synchronization of Regasified LNG & Pipe Lines.

Unit V-Natural Gas Storage (10 Hours)

Line Pack, Underground Natural Gas Storage, Aquifers, Manmade caverns.

Text Books

1. *Negi B.S., 2008. “LNG-An Indian Scenario”, Technology Publications.*
2. *Rojey A. & Jaffret C., 1997.“Natural Gas-Production, Processing, Transport”, Editions Technip-PariS.*

Reference Books

1. Saeid. Mokhatab, William A. Poe & James G. Speight, 2006. *Handbook of Natural Gas Transmission and Processing*, Gulf Professional Publishing.
2. G. G. Nasr & N. E. Connor, 2014 *Natural Gas Engineering and Safety Challenges*", Springer.

Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination
Examination Scheme:

Components	MSE	Presentation/Assignment/ etc	ESE
Weightage (%)	20	50	30

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

PO/ CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3
CO1	3	3	3	-	-	-	-	-	-	-	-	-	1	1	1
CO2	-	3	3	-	-	-	-	-	-	-	-	-	1	1	1
CO3	-	-	3	-	-	-	-	-	-	-	-	-	1	1	1
CO4	3	-	3	-	-	-	-	-	-	-	-	-	1	1	1
Avg	3	3	3	-	-	-	-	-	-	-	-	-	1	1	1

1=weakly mapped 2= moderately mapped 3=strongly mapped

PEGS4018P	Applications of GIS	L	T	P	C
Version 1.0		3	0	0	3
Pre-requisites/ Exposure					
Co-requisites/ Exposure					

Course objectives:

1. To help students learn and understand the fundamentals and applications of Geospatial technology in various sectors and enable them to provide spatial analytical solutions to applied problems and aid in decision making.
2. To expose the students to understand the concepts of remote sensing, data acquisition in remote sensing and characteristics of satellite data.
3. To empower students with the knowledge of integrated use of remote sensing and GIS for, monitoring, planning and management of energy sources and hydrocarbons.

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

CO1	Understand how to capture, import, structure, analyze and present geographical data and understand the different spatial data types and geographical data base management.
CO2	Analyze the purposes of GIS and the kinds of problems to which GIS is applied.
CO3	Analyze the concept of remote sensing and data acquisition and able to evaluate the basic characteristics and efficiency of remote sensing data for different remote sensing applications.
CO4	Apply the integrated use of GIS, remote sensing and GPS techniques in various Energy domains through case studies.

Catalog Description:
In India nowadays, the distribution of city gas is a significant industry. Natural gas is a flexible fuel with uses in many industries. In terms of economics and environmental benefits, natural gas is excellent. City gas distribution refers to the provision of gas to the residential, commercial, industrial and transportation sectors at various pressure levels. This course is focused on the automation of the CGD (City Gas Distribution) industry, revolutionizing the way natural gas is distributed and enhancing operational efficiency. Cutting-edge solutions and innovative technologies are designed to streamline processes, optimize resource utilization, and ensure seamless operations for CGD companies.

Course Content (Theory):
Unit 1: Fundamentals of GIS, GPS & Applications: (12 Hours)
GIS Fundamentals, GPS measurements, Vector, Raster and Attribute Data Models, Vector and Raster Data Structure, Spatial Data Input and Editing, Visualization and Query of Spatial Data, Datum, Map Scale, Coordinate systems and Projections, Digital Representation of Map data, Data types and Representation, Visualization and processing of spatial and temporal data, Global Positioning Systems (GPS) and Applications.
Unit 2: Fundamentals of Remote Sensing: (13 Hours)
Definition and Overview of Remote Sensing History and Evolution of Remote Sensing and Remote Sensing Systems Electromagnetic Radiation, Sensors and scanners, Satellites and their

characteristics; Remote Sensing Systems - Active and Passive Systems, Imaging and Non-Imaging Systems, Concept of Resolutions in remote sensing - Spatial, Spectral, Radiometric and Temporal; Ground truth data collection - use of radiometers, and spectrophotometers, etc. Spectral Reflectance, Spectral Reflectance curves, Data acquisition and Interpretation, Image characteristics, Image data Formats, Image Rectification and Restoration Techniques, Geometric and Atmospheric Correction, Digital Image processing.

Unit 3: Geospatial database: (10 Hours)

Definition, Features of Spatial Databases, Concepts and Models of Spatial Databases, Geodatabase characteristics, elements and applications, Spatial Data Types, Spatial Relationships, Database Querying: Fundamental Operations (Algebra: Spatial Selection, Spatial Join, Spatial Function Application), Spatial and Non-spatial Data Processing: Storage and Management of Spatial Data.

Unit 4: Applications of Remote Sensing and GIS: (10 Hours)

Remote sensing and GIS for solving multi criteria problems, Energy source visualization, Mapping Energy Sources Using GIS and GPS, , Remote sensing and GIS for mineral exploration, Natural hazard zonation and mapping, Remote sensing in oil exploration – features helpful in detection of target areas for oil exploration, oil slick mapping, RS and GIS in downstream, Geospatial mapping of Renewable Energy sources, Data information extraction and development of decision support system.

TEXTBOOKS

1. Introduction to Geographic Information Systems by Kang-tsung Chang 2002; Tata McGraw Hill, New Delhi.
2. Textbook of Remote Sensing and Geographical Information systems by M. Anji Reddy,
3. Remote sensing and Image Interpretation, Wiley 7th Edition, – Lillesand, Keifer & Chipman, 2015, 768pp
4. Assessment of Energy Sources Using GIS by Lubos Matejicek, March 2017, Springer

Reference books

1. Longley, P.A., M. Goodchild., D.J. Maguire and D.W. Rhind. Geographical information systems and science, John Wiley & Sons, Chichester, 4th edition, 2015.
2. Fundamentals and Applications of Renewable Energy By Mehmet Kanoglu, Yunus Cengel and John Cimbala, McGraw-Hill Education, 2019.

Examination Scheme:

Components	**Midterm**	**Internal Assessment**	**End Term Examination**
Weightage (%)	20	50	50

Correlation between the Program Outcomes (POs), Program Specific Outcomes (PSOs) and Course Outcomes (COs)

PO/ CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	3	1	1	2	-	-	-	-	-	-	-	3	1	-
CO2	2	1	1	1	-	-	-	-	-	-	-	3	1	-
CO3	2	2	2	2	-	-	-	-	-	-	-	3	1	-
CO4	1	2	3	3	-	-	-	-	-	-	-	3	1	-
Avg	**2**	**1.5**	**1.75**	**2**	-	-	-	-	-	-	-	**3**	**1**	-

	Automation of CGD Industry	L	T	P	C
Version 1.0		3	0	0	3
Pre-requisites/ Exposure	Natural Gas Engineering, City Gas Distribution				
Co-requisites/ Exposure					

Course Objectives

1) Understand the fundamental principles and concepts of automation in the CGD industry.
2) Gain knowledge of various automation technologies, such as automated gas metering systems, smart grid management, leak detection and repair solutions, robotics, and integrated SCADA systems.
3) Identify and analyze the benefits and potential challenges associated with implementing automation in CGD operations.
4) Evaluate the impact of automation on operational efficiency, cost savings, safety, customer service, and environmental sustainability.
5) Comprehend the role of automation in improving safety and reducing environmental impact in CGD operations.

Course Outcomes

CO1	Understanding automation in CGD industry
CO2	Applying AI technologies to CGD industry
CO3	Analysing the data and results from AI derived processes

Course content

Unit 1**. Introduction to automation mainly covering the principles of automation, SCADA etc**. **(10 Hours)**

Unit 2. **Working principles of automation in CGD equipment** **(8 Hours)**

- Valves, Compressors, Dispensers, Metering skid, Odorization, Pressure reduction skid 3**.**

Unit 3. Automation is O&M **(8 Hours)**

PNG (Steel and MDPE network), CNG (CNG station), City Gate Station.

Unit 4. Automation in ERDMP : **(6 Hours)**

Early Warning Systems, Decision Support Systems, Communication and Coordination:

Unit 5. Gas metering & Digital Twins **(7 Hours)**

Smart Gas Meters, Automated Meter Reading (AMR), Data Management and Analytics, Demand Response and Billing, Introduction to Digital Twins, Digital Twin Applications in Gas Metering, Data Integration and IoT, Simulation and Optimization.

Unit 6. Automation for old CGD network **(6 Hours)**

Network Retrofitting and Upgrades, Leak Detection and Monitoring, Remote Valve Control, Pressure Regulation and Management,

Reference Books

1. Rojey A. & Jaffret C., (1997) “Natural Gas-Production, Processing, Transport”, Editions Technip-Paris,
2. G. G. Nasr & N. E. Connor, (2014) “Natural Gas Engineering and Safety Challenges”, Springer,

3. J. Love (2007)“ Process Automation Handbook: A Guide to Theory Practice “ Springer

CO/PO Mapping for the course

PO/CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	3	3	3	-	-	-	-	-	-	-	-	-	1	1	-
CO2	3	3	3	-	-	-	-	-	-	-	-	-	1	1	-
CO3	3	3	3	-	-	-	-	-	-	-	-	-	1	1	-
CO4	3	3	3	-	-	-	-	-	-	-	-	-	1	1	-
CO5	2	2	2	-	-	-	-	-	-	-	-	-	1	1	-
Avg	3	3	3	-	-	-	-	-	-	-	-	-	1	1	-

Digitalization of Process Technology

CHGS3132P	**Process Modelling, Simulation, and Optimization**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**
Pre-requisites/Exposure					
Co-requisites					

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. Understand the fundamentals of mathematical models, optimization methodology to study chemical engineering processes.

CO2. Implement computational methods to simulate the dynamics and behaviour of various fluid flow, heat and mass transfer operations, reactions, process equipment and flow sheet.

CO3. Utilize commercial software to simulate and obtain optimized solutions to various chemical engineering problems.

CO4. Develop an efficient mathematical model for fluid flow, heat and mass transfer, reaction operations and their equipment and simulation strategy.

Course Content:

Unit 1: 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.	10 Hours
Unit 2: 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.	15 Hours
UNIT 3: 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.	10 Hours
Unit 4: Process Optimization One-dimensional unconstrained optimization (Golden section search, Parabolic interpolation, Newon's Method), Multi-dimensional unconstrained optimization (Direct	10 Hours

Methods and gradient methods), Constrained optimization (Lagrangian multiplication method, Conjugate gradienr method, Powell's method).	

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

PO/CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2
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

TEXTBOOK:

- 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 Press (2015)

CHCE3055P	Chemical process and Data Analytics	L	T	P	Cr
Version 4.0		**3**	**0**	**0**	**3**
Pre-requisites/Exposure	Engineering mathematics				
Co-requisites	--				

Course Objectives

9. Understand the fundamental concepts and techniques of data analytics and machine learning.
10. Develop proficiency in data pre-processing, cleaning, and exploratory data analysis.
11. Gain knowledge of a wide range of supervised and unsupervised learning algorithms and their applications.
12. Learn to evaluate and validate machine learning models using appropriate performance metrics and cross-validation techniques.
13. Acquire skills in feature selection and engineering to improve model performance and interpretability.
14. Explore neural networks and deep learning algorithms for more complex machine learning tasks.
15. Learn about big data analytics and cloud computing platforms for handling large-scale data.
16. Develop an awareness of ethical considerations and bias in machine learning, and understand privacy and security issues.

Course Outcomes

On the completion of this course, the student will be able to:

CO1	Define and explain the terms as well as concepts involve in handling big data, its analysis, and learning algorithm
CO2	Compare various learning algorithms based on the strength and limitations.
CO3	Collect a data as well as prepare a big data set by applying data cleaning and transformation technique.
CO4	Analyze complex datasets and demonstrate the patterns, correlations, and its trend by using various learning algorithms

Co-Relationship Matrix

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	3	2	1	2	2	1	1	1	1	2	1	1	1	1
CO2	3	2	1	2	2	1	1	1	1	1	1	1	1	1
CO3	3	3	2	3	2	1	1	1	1	1	1	1	1	1
CO4	3	3	2	3	2	1	1	1	2	3	2	1	1	1
Avg	3	2.5	1.5	3	2	1	1	1	1.3	1.75	1.25	1	1	1

Course description

The Data Analytics and Machine Learning course provides a comprehensive understanding of data analytics and machine learning concepts and applications. Students will learn essential techniques for data pre-processing, exploratory data analysis, and feature engineering. They will explore supervised learning algorithms like linear regression, logistic regression, decision trees, and support vector machines for classification and regression tasks. Unsupervised learning algorithms, including clustering and dimensionality reduction, will be covered. Feature selection and model interpretability methods will be explored to enhance model performance and gain insights. The course introduces neural networks, deep learning, and their applications in image classification and natural language processing. Students will gain skills in time series analysis and forecasting. They will also learn about big data analytics and cloud computing platforms. Ethical considerations and biases in machine learning will be addressed.

Course Content

UNIT I: Introduction to Data Analytics and Machine Learning — **5 Hours**

Overview of data analytics and its importance, introduction to machine learning and its applications, key concepts, and terminology

UNIT II: Data Preprocessing and Exploratory Data Analysis — **8 Hours**

Data collection and cleaning, handling missing data and outliers, data transformation and feature engineering, exploratory data analysis techniques

Unit III: Supervised Learning Algorithms — **8 Hours**

Clustering algorithms (e.g., K-means, hierarchical clustering), Dimensionality reduction techniques (e.g., Principal Component Analysis, t-SNE), Association rule mining, Feature importance and selection techniques

Unit IV: Unsupervised Learning Algorithms and Feature Selection — **8 Hours**

Clustering algorithms (e.g., K-means, hierarchical clustering), Dimensionality reduction techniques (e.g., Principal Component Analysis, t-SNE), Association rule mining, Feature importance and selection techniques

Unit V: Model Evaluation, Validation, and Interpretability — **8 Hours**

Training and testing datasets, Performance metrics for classification and regression models, Cross-validation techniques, Hyperparameter tuning, Model interpretability and explainability

Unit VI: Neural Networks — **8 Hours**

Introduction to neural networks, Multilayer perceptrons, Convolutional neural networks (CNNs), Recurrent neural networks (RNNs), Transfer learning, Natural Language Processing (NLP), Time series analysis, Ethical considerations, and bias in machine learning

Textbooks

1. McKinney, W. (2017). Python for Data Analysis: Data Wrangling with Pandas, NumPy, and IPython. United States: O'Reilly Media.John Zelle, Python Programming: An Introduction to Computer Science
2. Hastie, T., Witten, D., James, G., Tibshirani, R. (2013). An Introduction to Statistical Learning: With Applications in R. Germany: Springer New York.
3. Bishop, C. M. (2006). Pattern Recognition and Machine Learning. Switzerland: Springer New York.

Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination
Examination Scheme:

Components	Internal Assessment	MSE	ESE
Weightage (%)	30	20	50

CHCE3056P	AUTOMATION OF CHEMICAL PROCESSES	L	T	P	C
Version 1.0		3	0	0	3
Pre-requisites/Exposure	Process control and process instrumentation				
Co-requisites	Chemical process safety				

Course Objectives

1. Understand the principles and concepts of process automation in chemical industries.
2. Learn the different types of sensors and instruments used in process automation.
3. Learn how to develop and implement control strategies for chemical processes.
4. Learn how to analyze, design, and optimize chemical processes using automation techniques.
5. Understand the roles of safety and regulatory compliance in process automation.

Course Outcomes (Cos)
On completion of this course, student will be able to
CO1. **Understand** the principles and concepts of automation in chemical processes.
CO2. **Apply** the knowledge of process instrumentation, including pressure, level, temperature, and flow sensors.
CO3. **Analyze** and troubleshoot common automation problems in chemical processes.
CO4. **Investigate** control systems, safety systems and emergency shutdown procedures.

Catalog Description
This course focuses on the automation of chemical processes, covering fundamental concepts and practical applications of automation in chemical engineering. Topics include process control fundamentals, process systems, advanced control strategies, plantwide control and optimization, and process safety considerations. Students will learn how to design and analyze control systems using various tools, such as process simulators and control software.

Course Content

Unit 1: Process safety and safe automation: Objective, scope, limitations, target audience, incidents that define safe automation.	**4 hours**
Unit 2: The role of automation in chemical process industry: Process operations, plant automation, a framework for process safety, risk-based design, risk management of existing facility.	**8 hours**
Unit 3: Automation specification: Process automation lifecycle, functional specification, designing for operating objectives, inherently safer practices, designing for core attributes, control, and safety system integration.	**10 hours**
Unit 4: Design and implementation of process control systems, safety controls, alarms, and interlocks (SCAI): Input and output field signal types, basic application program functions, process control objectives, process controller technology selection, detailed application program design, SCAI classification, design considerations, SCAI technology selection.	**14 hours**
Unit 5: Administrative control and monitoring: Introduction, automation organization management, process safety information, operating procedures, maintenance planning, human and systematic failure management, management of change.	**9 hours**

Textbook:

1. Guidelines for safe automation of chemical processes, 2nd edition by Victor Joseph Maggioli Sr., John Wiley & Son Publisher.

Reference Books

Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination
Examination Scheme:

Components	Seminar/review paper/Mid Semester Exam	Internal assessment	ESE
Weightage (%)	20	30	50

Co-Relationship Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO 1	3	2												3
CO 2	3	3	3	2	2									3
CO 3	2													3
CO 4	3	2	2	2										3
Avg	2.75	1.75	1.25	1	0.5									3

CSIS4010P	INDUSTRIAL INTERNET OF THINGS	L	T	P	C
Version 1.0		3	0	0	3
Pre-requisites/Exposure	Basic knowledge of computer and internet				
Co-requisites					

Course Objectives

1. Understanding the concept and fundamentals of the industrial internet of things (IIoT)
2. Understand the importance and potential benefits of IIoT for business and industries.
3. Understand the challenges and possible risks associated with IIoT implementation.
4. Learn about the different technologies and platforms involved in IIOT such as sensors, data analysis, cloud computing, and cybersecurity.
5. Learn how to design and configure IIoT solutions for industrial applications.

Course Outcomes (Cos)

On completion of this course, the students will be able to
CO1. **Recognize** the application of IIoT in various industries.
CO2. **Understand** the key components of an IIoT system such as sensors, devices, gateways.
CO3. **Apply** IIoT protocol to upload sensor data and to control devices.
CO4. **Examine** IIoT application.

Catalog Description

The IoT market is quickly expanding, with an installed base of approximately 30 billion devices in 202 0 estimated to increase to 75 billion devices by 2025. This course introduces the fundamentals of IIoT technologies, applications, and solutions. Students learn how to design, develop, and deploy IIoT solutions in various industry sectors, including manufacturing, agriculture, healthcare, transportation, and energy.

Course Content

Unit I: **Introduction to Internet of Things**: IIoT Definition, Introduction to IIoT and its application in industrial settings, IIoT characteristics, Architecture and components of IIoT, Physical design of IoT, Logical Design of IIoT, Overview of IIoT protocols, IIoT levels and deployment templates, Challenges for IIoT, Interdependencies of IIoT and cloud computing, Web of things	**6 Hour**
Unit II: Embedded IoT devices: Sensors and actuators for IoT applications, IoT components and implementation, Programming of Node MCU and Raspberry PI, Implementation of IoT with Edge devices, Reading sensor data and transmit to cloud, Controlling devices through cloud using mobile application and web application, Types and configurations of gateways, Specifications of IoT gateways (Practical aspects of this chapter should be covered during lab sessions)	**10 Hour**
Unit III: IoT Protocols: Link layer protocols, Network/internet layer protocols, Transport layer protocols, Application layer protocols: Hypertext transfer protocol (HTTP), Systematic HTTP access methodology, Web Socket, Constrained application protocol CoAP), Message Queue Telemetry Transport Protocol (MQTT), XMPP, DDS, AMQP	**11 Hour**
Unit IV: IoT Security and challenges: IOT Security, Dangers, Assigning values to Information, Security Components, Key Management, Update Management, Challenges in IoT security.	**10 Hour**
Unit V: IoT Applications and case study: Broad categories of IoT applications: Consumer IoT, Commercial IoT, Industrial IoT, Infrastructure IoT, Military Things (IoMT). IoT Case studies: Home automation with IoT, River water pollution monitoring, Smart city street light control and monitoring, Health care monitoring, Voice Apps on IoT device	**8 Hour**

Textbook:

Reference Books

1. Rahul Dubey, “An Introduction to Internet of Things: Connecting Devices, Edge Gateway, and Cloud with Applications”, Cengage India Publication

2. Raj Kamal, “Internet of Things: Architecture and Design Principles, Mc Graw Hill Education
3. Hanes et al “IoT Fundamentals”, Cisco Press
4. Vijay Madisetti and Arshdeep Bahga, “Internet of Things (A Hands-on-Approach)”, , Paperback, 2015.
5. A. McEwen, H. Cassimally, “Designing the Internet of Things”, Wiley, 2013.
6. Yashwant Kanetkar, “21 Internet of Things Experiments”, Kindle edition
7. Adeel Javed, “Building Arduino projects for Internet of Things”, Apress publication
8. Donald Noris, “The Internet of Things: Do it yourself Projects with Arduino, Raspberry PI and BeagleBone Black” Mc Graw Hill Publication
9. Adrian McEwen & Hakim Cassimally, “Designing the Internet of things”, Willey publication.

Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination

Examination Scheme:

Components	Seminar/review paper/Mid Semester Exam	Internal assessment	ESE
Weightage (%)	20	30	50

Co-Relationship Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3													
CO2	3	2		2										1
CO3	3				3									2
CO4	3	3	3	3										2
Avg	3	1.25	0.75	1.25	0.75									1.25

CHCE4031P	Process 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 materials

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

CO1 Understand the significance of digitalization in chemical process industry.

CO2 Analyze various advanced production technologies.

CO3 Evaluate the feasibility of technologies for conversion of biomass to fuels and chemicals.

CO4 Design equipment used in the separation of biomass.

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 chemical 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:

Unit 1: Digitalization of Chemical Process Industry 9 hours
Application of Artificial Intelligence (AI) in panel monitoring and instrumentation - Application of Internet of Things (IoT) in plant operation

Unit 2: 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. 9 hours

Unit 3: Bio-refinery 9 hours
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.

Unit 4: Separation techniques for biomass and products in biomass conversion 9 hours
Physical treatment – Mechanical treatment- Chemical treatments. Design of equipment.

Unit 5: Sustainable materials 9 hours
Biodegradable-Biocompatible polymers for packaging and medicinal applications. Sustainable adsorbents for removal of pesticides from water and pharmaceuticals from wastewater.

Textbooks:

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.

References:

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.
5. Vinayagam V, Murugan S, Kumaresan R, Narayanan M, Sillanpää M, Viet N Vo D, et al. Sustainable adsorbents for the removal of pharmaceuticals from wastewater: A review. Chemosphere 2022;300:134597. https://doi.org/https://doi.org/10.1016/j.chemosphere.2022.134597.

6. Ponnuchamy M, Kapoor A, Senthil Kumar P, Vo D-VN, Balakrishnan A, Mariam Jacob M, et al. Sustainable adsorbents for the removal of pesticides from water: a review. Environ Chem Lett 2021;19:2425–63. https://doi.org/10.1007/s10311-021-01183-1.

CO/PO Mapping for the course:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2			3		3						2	
CO2	2	2					3						2	
CO3	3	3					3							3
CO4	2	2					3							
CO5	3	3					3						3	3
Avg	2.4	2.4			3		3						2.3	3

MINOR in CHEMICAL ENGINEERING

Course Code	INTRODUCTION TO CHEMICAL ENGINEERING	L	T	P	C
Version 1.0		4	0	0	4
Pre-requisites/Exposure	Physics, Chemistry, Engineering Mathematics I				
Co-requisites					

Course Objectives

1. To introduce the concepts that will enable the transition from science to chemical engineering.
2. Explanation of role of chemical engineers in everyday life and the importance of chemical engineering.
3. To learn the various unit operations and unit processes used in chemical industries.
4. To learn the role of chemical engineers in environmental and safety aspects in process industries.

Course Outcomes (Cos)

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

CO1. **Identify** the role of Chemical Engineers in everyday life and the importance of Chemical Engineering.
CO2. **Summarize** the role of various Unit Operations and Unit Processes in Chemical industries.
CO3. **Demonstrate** the role of fluid mechanics, thermodynamics, reaction kinetics, heat, mass, and momentum transfer in the field of Chemical Engineering.
CO4. **Apply** the knowledge to solve industrial problems.

Catalog Description

Introduction to Chemical Engineering is a foundational course that introduces students to the basic principles and concepts of chemical engineering. This course covers various topics related to the application of chemistry, physics, and thermodynamics to designing and operating chemical processes. This course curriculum typically includes Introduction to chemical engineering, Material and Energy balances, Unit operations, Properties of fluids, Heat transfer, Mass transfer, Mechanical unit operations. Students will be expected to apply these principles to solve real world engineering problems and design processes that meet specific requirements.

Course Content

Unit I: Introduction, Chemical Engineering in daily life, Development of Chemical engineering from Lab scale to Plant scale, Role of Chemical Engineers in Chemical process industry	7 hours
Unit II: Basic concepts of analysis of processes, unit operations, units and dimensions, Material and Energy balances: Stoichiometry, energy conservation, and material flow analysis, Fundamentals of fluid mechanics, classification of fluids, properties of fluids: viscosity, density, velocity profile, flow field, types of fluid motion, flow of a fluid past a solid surface, pumps	16 hours
Unit III: Introduction to Heat transfer, Conductive, convective, and radiative heat transfer, Heat transfer equipments: heat exchangers, evaporators, types of evaporators, methods of feeding, Laws of thermodynamics, system, surrounding, Thermodynamic equilibrium, state, path, process, reversible and irreversible process.	10 hours
Unit IV: Introduction to Mass transfer, Law of diffusion, classification of separation processes and applications, basic definitions of separation processes (Distillation, Liquid-Liquid extraction, solid-liquid extraction, absorption, adsorption, drying, and crystallization), boiling point diagram, LLE, VLE.	12 hours

Unit V: Introduction to mechanical operations: Size reduction, filtration, basic differences between agitation and mixing, Basic definition of Chemical Reaction, definition of reaction rate, classifications of reactions, variables affecting the rate of reaction, Types of reactions and reactors, Order and Molecularity of the reaction, Elementary and Non-Elementary Reactions, rate constant — 15 hours

Textbook:

1. Chemical Engineering-An Introduction, Morton M. Denn, Cambridge University Press, 2013.
2. Introduction to Chemical Engineering, S. Pushpavanam, PHI learning Pvt. Ltd., 2012.
3. Introduction to Chemical Engineering, Walter L. Badger, Julius T, Banchero, TMH Publications, 2008.

Reference Books

1. Unit operations in Chemical Engineering, W.L. McCabe and J.C. Smith and Peter Harriott, McGraw Hill, 5th Ed. 1993.

Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination

Examination Scheme:

Components	Seminar/review paper/Mid Semester Exam	Internal assessment	ESE
Weightage (%)	20	30	50

Co-Relationship Matrix

Program Outcomes / Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO 1	3	2												2
CO 2	3	3	3	2										2
CO 3	3	3	3	3			3							2
CO4	3	3	3	3										3
Avg	3	2.75	2.25	2			0.75							2.25

Version Control

Details		Name	Date
Created by	Cluster Head/ Programme head		
Checked by	IQAC		
Approved by	Dean		

CCC/ DCC meeting date	
Board of Studies Approval Date	
AC subcommittee approval date	
Academic Council approval Date	

Version: **Approval Date:**