B.Tech in
CHEMICAL ENGINEERING
SCHEME OF INSTRUCTION AND SYLLABI
(As per NEP-2020 Guidelines)

(Effective from Academic Year 2025-26)

UNIVERSITY SCHOOL OF CHEMICAL ENGINEERING
GURU GOBIND SINGH INDRAPRASTHA UNIVERSITY
SECTOR 16C, DWAKRA, NEW DELHI – 110078
www.ipu.ac.in

About the School

University School of Chemical Technology

The **University School of Chemical Technology (USCT)**, a constituent school of **Guru Gobind Singh Indraprastha University (GGSIPU)**, New Delhi, was established in 1999. The school was founded with the twin objectives of producing skilled professionals and keeping pace with the research and development activities of the rapidly evolving chemical and allied engineering field. USCT offers Dual Degree (B.Tech. & M.Tech.), M.Tech., Ph.D. programs in Chemical Engineering, and B.Tech. in Energy Engineering. The dual degree program is particularly noteworthy as it provides an integrated pathway to obtain both undergraduate and postgraduate degrees. The course curriculums of various programs are designed to blend core chemical engineering fundamentals with emerging areas such as environmental engineering, process modelling and simulation, and energy engineering. The scheme and syllabus for all programs are in line with **AICTE** and **NEP-2020 guidelines**. The school boasts a dynamic team of qualified, experienced faculty members, many of whom are alumni of prestigious institutes like IITs and NITs. The school strongly emphasizes collaborative research. Apart from publishing research findings in internationally reputable peer-reviewed journals, USCT faculties are also involved in various extramural research projects funded by government agencies like **CSIR, SERB-DST, and DBT**.

The school has well-equipped laboratories required for B.Tech. and M.Tech. programs. The school also has dedicated instrumentation and computational facilities equipped with state-of-the-art software, i.e., ASPEN Plus, MATLAB, COMSOL, Design-Expert, and Ansys Fluent. The school maintains a strong interface with the industry, offering students opportunities for internships, industrial visits, and placements in leading companies. USCT, located in GGSIPU's Dwarka campus, provides a vibrant academic environment, excellent infrastructure, and access to cutting-edge research opportunities in the National Capital Region (NCR). USCT is an obvious choice for students aspiring to build a career in chemical and energy engineering because of its strong academic foundation, research focus, and industry exposure.

VISION OF THE SCHOOL

To be a globally recognised centre for education and research by achieving excellence through active teaching, skill development and research in chemical and allied engineering.

MISSION OF THE SCHOOL

- Providing high-quality teaching and training to students to meet the challenges in the chemical and allied engineering areas with changing needs of the industry.
- Generating knowledge and developing inclusive technologies with a focus on sustainability.
- Team up with industries and research institutes to cater to community needs.

LIST OF PROGRAMS OFFERED BY THE SCHOOL

Program	Title of the Program
B.Tech./Mech. (Dual Degree)	Chemical Engineering
B.Tech.	Energy Engineering
M.Tech.	Chemical Engineering
Ph.D.	Chemical Technology

Program Educational Objectives (B.Tech – Chemical Engineering)

After four years of graduation

PEO-1	Graduates will possess a strong foundation in fundamental science and engineering, empowering them to identify, pursue, and achieve their personal and professional goals.
PEO-2	Graduates will acquire interdisciplinary knowledge and be capable enough to develop inclusive technologies focusing on sustainability and addressing global challenges.
PEO-3	Graduates will be equipped with a strong spirit of teamwork, effective communication skills, and ethical values to contribute to societal and technological advancements responsibly.

Program Articulation Matrix

PEO / **Mission statements**	**PEO-1**	**PEO-2**	**PEO-3**
Providing high-quality teaching and training to students to meet the challenges in the chemical and allied engineering areas with changing needs of the industry.	3	3	2
Generating knowledge and developing inclusive technologies with a focus on sustainability.	3	2	2
Team up with industries and research institutes to cater to community needs.	-	1	3

1 - Slightly 2 - Moderately 3 - Substantially

Program Outcomes (POs)

PO-1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO-2	**Problem analysis:** Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO-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.
PO-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.
PO-5	**Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
PO-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.
PO-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.
PO-8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO-9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO-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.
PO-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.
PO-12	**Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific Outcomes (PSOs)

PSO-1	Identify, analyze and solve complex problems encountered in chemical and other allied industries, by applying the principles of chemical engineering and using modern engineering tools such as ASPEN PLUS, MATLAB, ANSYS, DESIGN-EXPERT etc.
PSO-2	Design and optimize the chemical process engineering systems, chemical plants and chemical products considering public health, safety and welfare, as well as global, social, environmental and economic aspects.
PSO-3	Play an important role in the diversified area of chemical engineering (Industries, Academia and R&D), and able to carry out multidisciplinary research.
PSO-4	Prepare students with high scholastic attainment to enter graduate programs leading to innovative degrees in chemical engineering or in related professional, scientific, and engineering fields.

Marking Scheme of Examination for all non-NUES courses (Theory/Practical)

	Marks Distribution		
	Teachers Continuous Evaluation (Minor Exam, Quiz, Assignment, etc.)	End Term Examination	Total Marks
For Theory Courses	**40**	**60**	**100**
For Practical Courses	**40**	**60**	**100**

CURRICULUM

Four-year undergraduate degree will be offered in the following three different categories:

1. **Bachelor of Technology** in Chemical Engineering
2. **Bachelor of Technology (With Research)** in Chemical Engineering
3. **Bachelor of Technology (Honours With Research)** in Chemical Engineering

Minimum credits requirement for the award of the Bachelor of Technology (B.Tech) degree in the respective categories are as follows:

		Minimum Credits to be earned for the award of		
Category of Courses	**Credit offered**	**Nomenclature of the degree**		
		B.Tech in Chemical Engineering	**B.Tech (with Research) in Chemical Engineering**	**B.Tech (Honours with Research) in Chemical Engineering**
Basic Science Courses (BSC)	19	19	19	19
Engineering Science Courses (ESC)	6	6	6	6
Multi-disciplinary Courses (MDC)@	9	9	9	9
Ability Enhancement Courses (AEC)	13	13	13	13
Skill Enhancement Courses (SEC)	21	21	21	21
Value-Added Courses (VAC)	8	8	8	8
Programme Core Courses (PCC)	95	**75**(=63**+12***)	**63****	**81**(= 63** + **18******)
Programme Elective course (PEC)	12	3	3	3
Research Project(PW)	18	6	18	18
Total	**201**	**160**	**160**	**178**

@USCT students should choose the MDC subject from the other school's offered course (from USS Dwarka Campus only)
**** From basic category course (PCC-1 to PCC-20); out of which PCC-3 to PCC-12, these ten courses are mandatory to pass for the award of the degree.**
***** From basic category course (PCC-24, PCC-25, PCC-26 & PCC-28).**
****** From honours category course (PCC-14, PCC-15, PCC-21, PCC-22, PCC-23 & PCC-27)**

- ***Students admitted through lateral entry admission into the second year of the B.Tech in Chemical Engineering program are exempted from completing the credits assigned to the first year of study. The total number of credits offered during the first year is 48 credits. Therefore, lateral entry students must complete 112 credits (i.e., 160 total credits minus***

48) between the third and eighth semesters to be eligible for the award of the Bachelor of Technology degree in Chemical Engineering. All other academic and graduation requirements for the degree will remain identical for both lateral entry students and those admitted through regular entry.

- **Students wish to pursue the Bachelor of Technology (with Research) degree must submit a formal consent letter in the school before the commencement of the third semester of their studies.**

- **To be eligible for pursuing the Bachelor of Technology (Honours with Research) degree, students must maintain a minimum of 75% marks through the first four semesters without any supplementary examinations. Additionally, they must have opted for the Bachelor of Technology (with Research) degree and are required to submit a formal application at the end of the fourth semester.**

- **In order to be awarded the B.Tech (Honours with Research) degree, students must earn an additional 18 credits at the honours level on top of the regular credit requirements prescribed for the B.Tech program.**

EXIT CRITERIA – B.TECH IN CHEMICAL ENGINEERING

(As per NEP 2020 Multi-Exit Framework)

To provide academic flexibility and align with the National Education Policy (NEP) 2020, the following **multi-exit options** are available to students enrolled in the B.Tech Chemical Engineering program:

1. Exit After First Year (Certificate)

- **Award:** Certificate in Chemical Engineering
- **Eligibility:**
  - Successful completion of **40 credits** of course work as per the approved curriculum.
  - Completion of **6–8 weeks of internship (4 credits)** in recognized chemical process industries or laboratories.

2. Exit After Second Year (Diploma)

- **Award:** Diploma in Chemical Engineering
- **Eligibility:**
  - Successful completion of **80 credits** of course work as per the approved curriculum.
  - Completion of **6–8 weeks of internship (4 credits)** in recognized chemical process industries or laboratories.

3. Exit After Third Year (B.Sc)

- **Award:** B.Sc in Chemical Engineering
- **Eligibility:**
  - Successful completion of **120 credits** of course work as per the approved curriculum.
  - Completion of **6–8 weeks of internship** in recognized chemical process industries or laboratories.

CATEGORY-WISE COURSE DETAILS

Basic Science Courses (BSC):

Sl.	Group	Course Name	Course Code	Credit
1	Mathematics	Engineering Mathematics –I	BS-117	3
2		Engineering Mathematics –II	BS-114	3
3	Chemistry	Engineering Chemistry-I	BS-115	3
4		Engineering Chemistry-II	BS-112	3
5		Engineering Chemistry Lab	BS-161	1
6	Physics	Engineering Physics - I	BS-119	2
7		Engineering Physics - II	BS-116	2
8		Engineering Physics Lab- I	BS-163	1
9		Engineering Physics Lab- II	BS-162	1
			Total	**19**

Engineering Science Courses (ESC):

Sl.	Course Name	Course Code	Credit
1	Engineering Mechanics	IT-107	3
2	Basics of Electrical Engineering	IT-104	3
		Total	**6**

Ability Enhancement Courses (AEC):

Sl.	Course Name	Course Code	Credit
1	Programming for Problem Solving	IT-101	3
2	Communication Skills	HS-130	2
3	Numerical Methods for Engineers	CT-201	2
4	Engineering Economics	HS-232	2
	AI in product Management (*MOOCs/Swayam#*)		
5	Summer Training / Summer Project	CT-357	2
6	Seminar-II	CT-356	2
		Total	**13**

Skill Enhancement Courses (SEC):

Sl.	Course Name	Course Code	Credit
1	Programming for Problem Solving Lab	IT-151	1
2	Workshop Technology	CT-150	1
	Programming in Python Lab	IT-160	
3	Engineering Graphics	IT-152	1
	Engineering Drawing and Computer Graphics (*MOOCs/Swayam#*)		
4	Fluid and Particle Mechanics Lab	CT-251	2
5	Heat Transfer Lab	CT-252	2
6	Mass Transfer Lab	CT-254	2
7	Chemical Reaction Engineering Lab	CT-351	2
8	Chemical Process Control Lab	CT-353	2
9	Computational Methods for Chemical Engineers Lab	CT-355	2
10	Fuel Technology Lab	CT-352	2
11	Process Modelling & Simulation Lab	CT-354	2
12	Summer Training/Project	CT-451	2
		Total	**21**

Value-Added Courses (VAC):

Sl.	Course Name	Course Code	Credit
1	Environment and Safety Engineering	CT-103	2
2	The Science of Happiness and Wellbeing **(from *MOOCs/Swayam*)**		2
	Human Values and Ethics	HVEE-114	
3	Seminar-I	CT-253	2

4	NSS/NCC/Cultural Clubs/ Technical Society/ Technical Club		CT-256	2
			Total	**8**

Programme Core Courses (PCC):

Sl.	Group	Course Name	Course Code	Credit
1	Basic Courses	Fundamentals of Chemical Engineering	CT-101	2
2		Chemical Process Calculation	CT-102	3
3		Fluid Mechanics	CT-203	3
4		Mechanical Operations	CT-205	4
5		Heat Transfer-I	CT-207	4
6		Engineering Thermodynamics	CT-209	4
7		Mass Transfer-I	CT-202	3
8		Heat Transfer-II	CT-204	3
9		Chemical Reaction Engineering-I	CT-206	4
10		Chemical Engineering Thermodynamics	CT-208	3
11		Chemical Process Control-I	CT-210	3
12		Mass Transfer-II	CT-301	3
13		Chemical Process Industries	CT-303	3
14		Computational Methods for Chemical Engineers	CT-309	4
15		Transport Phenomena	CT-302	4
16		Process Modelling & Simulation	CT-304	4
17		Process Equipment Design	CT-306	4
18		Fuels and Combustion	CT-308	3
19		Industrial Pollution Control	CT-402	3
20		Introduction to Biochemical Engineering	CT-404	4
21		Analytical Methods in Engineering	CT-406	3
22		Analytical Methods in Engineering Lab	CT-450	2
			Total (Basic)	**73**
23	**Honours Courses**	**Chemical Process Control-II**	**CT-305**	**3**
24		**Chemical Reaction Engineering-II**	**CT-307**	**3**
25		**Mathematical Methods in Chemical Engineering**	**CT-401**	**4**
26		**Chemical Process Safety & Risk Management**	**CT-403**	**4**
27		**Chemical Process Engineering and Economics**	**CT-405**	**4**
28		**Chemical Process Optimization**	**CT-408**	**4**
			Total (Honours)	**22**
			Total (Basic + Honours)	**95**

Programme Elective Courses (PEC):

Sl.	Group	Course Name	Course Code	Credit
1	**Elective-I**	Fundamentals of Polymer Engineering	CT-311	3
2		Air Pollution Control Engineering	CT-313	
3		Alternative Energy Sources	CT-315	
4		Upstream Processing for Bioprocesses	CT-317	
5	**Elective-II**	Multiphase Reactor	CT-310	3
6		Water Pollution and Abatement	CT-312	
7		Energy Audit for Process Industries	CT-314	
8		Biological Reactors	CT-316	
9	**Elective-III**	Statistical Analysis of Process Data	CT-407	3
10		Solid Waste Management	CT-409	
11		Hydrogen and Fuel Cell	CT-411	
12		Industrial Biotechnology	CT-413	
13	**Elective-IV**	Introduction to Computational Fluid Dynamics	CT-415	3
14		Environmental Impact Assessment	CT-417	
15		Biosensor and Diagnostic Devices for Healthcare Applications	CT-419	
16		Biochemical Processes	CT-421	
			Total	**12**

1. ***The students should register MOOCs/Swayam (online) courses after obtaining prior approval from the Dean of the school.***
2. ***The BoS recommended absolute grading policy for online courses.***
3. ***A student can register a maximum of 12 credits as online courses during the entire program of study.***
4. **Registration fees for the MOOCs/SWAYAM courses will be borne by the students**

CREDIT DISTRIBUTION

Group	Semester (Credits)								Total Credits
	I	II	III	IV	V	VI	VII	VIII	
BSC	10	9							19
ESC	3	3							6
MDC	3	3	3						9
AEC	3	2	2	2	2	2			13
SEC	1	2	2	4	6	4	2		21
VAC	2	2	2	2					8
PCC	2	3	15	16	16	15	12	16	95
PEC					3	3	6		12
PW							6	12	18
Total	**24**	**24**	**24**	**24**	**27**	**24**	**26**	**28**	**201**

ACRONYMS & DEFINITIONS

BSC: Basic Science Courses
ESC: Engineering Science Courses
MDC: Multidisciplinary Courses
AEC: Ability Enhancement Courses
SEC: Skills Enhancement Courses
B: Basic course

VAC: Value-Added Courses
PCC: Programme Core Courses
PEC: Programme Elective course
PW: Research Project Work
H: Honours course

- The **batch** of the student shall mean the year of the first-time enrolment of the students in the programme of study in the first semester. Lateral entry students admitted in the 3rd semester/ 2nd year shall be designated as students admitted in the previous batch as they are admitted one year later. A student re-admitted in a programme of study in a lower/later batch shall be considered as the student of the original batch for the purpose calculation of duration of study.
- **Programme of study** shall mean Bachelor of Technology.
- Paper / Course shall be treated as synonyms. A paper is one unit of curriculum taught, in general, in one particular semester, having up to 4 credits.

SCHEME

First Year (UG-Certificate)

FIRST SEMESTER

Sl.	Paper ID	Course Code	Course Name	Category Code	Type: Basic (B)/ Honours (H)	Contact L – T - P	Credits
1		BS-115	Engineering Chemistry-I	BSC-1	B	3 – 0 – 0	3
2		BS-117	Engineering Mathematics –I	BSC-2	B	3 – 0 - 0	3
3		BS-119	Engineering Physics - I	BSC-3	B	2– 0 – 0	2
4		IT-101	Programming for Problem Solving	AEC-1	B	3 – 0 – 0	3
5		IT-107	Engineering Mechanics	ESC-1	B	3 – 0 – 0	3
6		CT-101	Fundamentals of Chemical Engineering	PCC-1	B	2 – 0 – 0	2
7		CT-103	Environment and Safety Engineering*	VAC-1*	B	2 – 0 – 0	2
8			**Multidisciplinary course (To be opted among the offered electives from other discipline)**	**MDC-1$**	**B**	**3 – 0 – 0**	**3**
9		IT-151	Programming for Problem Solving Lab	SEC-1	B	0 – 0 – 2	1
10		BS-161	Engineering Chemistry Lab	BSC-4	B	0 – 0 – 2	1
11		BS-163	Engineering Physics Lab - I	BSC-5	B	0 – 0 – 2	1
			Total			**27**	**24**

SECOND SEMESTER

Sl.	Paper ID	Course Code	Course Name	Category Code	Type: Basic (B)/ Honours (H)	Contact L – T - P	Credits
1		BS-112	Engineering Chemistry-II	BSC-6	B	3 – 0 – 0	3
2		BS-114	Engineering Mathematics –II	BSC-7	B	3 – 0 – 0	3
3		BS-116	Engineering Physics - II	BSC-8	B	2 – 0 – 0	2
4		HS-130	Communication Skills	AEC-2	B	2 – 0 – 0	2
5		CT-102	Chemical Process Calculation	PCC-2	B	3 – 0 – 0	3
6		IT-104	Basics of Electrical Engineering	ESC-2	B	3 – 0 – 0	3
7		**MOOCs – 1**	**The Science of Happiness and Wellbeing * (*MOOCs/Swayam#*)**	VAC-2*	B	2 – 0 – 0	2
		HVEE-114	Human Values and Ethics *				
8			**Multidisciplinary course (To be opted among the offered electives from other discipline)**	**MDC-2$**	**B**	**3 – 0 – 0**	**3**
9		CT-150	Workshop Technology	SEC-2	B	0 – 0 – 2	1
		IT-160	Programming in Python Lab				
10		IT-152	Engineering Graphics	SEC-3	B	0 – 0 – 2	1
		MOOCs – 2	**Engineering Drawing and Computer Graphics (*MOOCs/Swayam#*)**				
11		BS-162	Engineering Physics Lab - II	BSC-9	B	0 – 0 – 2	1
			Total			**27**	**24**

$ USCT students should choose the MDC subject from the other school's offered course (from USS Dwarka Campus only).
***NUES: Comprehensive evaluation will be done by the teacher concerned out of total 100 marks. No end term examination shall be held.**
#Registration fees for the MOOCS/SWAYAM courses will be borne by the students.

Second Year (UG-Diploma)

THIRD SEMESTER

Sl.	Paper ID	Course Code	Course Name	Category Code	Type: Basic (B)/ Honours (H)	Contact L – T - P	Credits
1		CT-201	Numerical Methods for Engineers	AEC-3	B	2 – 0 – 0	2
2		CT-203	Fluid Mechanics	PCC-3	B	3 – 0 – 0	3
3		CT-205	Mechanical Operations	PCC-4	B	4 – 0 – 0	4
4		CT-207	Heat Transfer-I	PCC-5	B	4 – 0 – 0	4
5		CT-209	Engineering Thermodynamics	PCC-6	B	4 – 0 – 0	4
6			**Multidisciplinary course (To be opted among the offered electives from other discipline)**	**MDC-3$**	**B**	**3 – 0 – 0**	**3**
7		CT-251	Fluid and Particle Mechanics Lab	SEC-4	B	0 – 0 – 3	2
8		CT-253	Seminar-I	VAC-3*	B	0 – 0 – 3	2
			Total			**26**	**24**

FOURTH SEMESTER

Sl.	Paper ID	Course Code	Course Name	Category Code	Type: Basic (B)/ Honours (H)	Contact L – T - P	Credits
1		CT-202	Mass Transfer-I	PCC-7	B	3 – 0 – 0	3
2		CT-204	Heat Transfer-II	PCC-8	B	3 – 0 – 0	3
3		CT-206	Chemical Reaction Engineering-I	PCC-9	B	4– 0 – 0	4
4		CT-208	Chemical Engineering Thermodynamics	PCC-10	B	3 – 0 – 0	3
5		CT-210	Chemical Process Control-I	PCC-11	B	3 – 0 – 0	3
6		HS-232	Engineering Economics	AEC-4	B	2 – 0 – 0	2
		MOOCs – 3	**AI in product Management (*MOOCs/Swayam#*)**				
7		CT-252	Heat Transfer Lab	SEC-5	B	0 – 0 – 3	2
8		CT-254	Mass Transfer Lab	SEC-6	B	0 – 0 – 3	2
9		CT-256	NSS/NCC/Cultural Clubs/ Technical Society/ Technical Club*	VAC-4*	B	0 – 0 – 0	2
			Total			**24**	**24**

$ USCT students should choose the MDC subject from the other school's offered course (from USS Dwarka Campus only).
***NUES: Comprehensive evaluation will be done by the teacher concerned out of total 100 marks. No end term examination shall be held.**
#Registration fees for the MOOCS/SWAYAM courses will be borne by the students.

Third Year (Advanced Diploma)

FIFTH SEMESTER

Sl.	Paper ID	Course Code	Course Name	Category Code	Type: Basic (B)/ Honours (H)	Contact L – T - P	Credits
1		CT-301	Mass Transfer-II	PCC-12	B	3 – 0 – 0	3
2		CT-303	Chemical Process Industries	PCC-13	B	3 – 0 – 0	3
3		**CT-305**	**Chemical Process Control-II**	**PCC-14**	**H**	**3 – 0 – 0**	**3**
4		**CT-307**	**Chemical Reaction Engineering-II**	**PCC-15**	**H**	**3 – 0 – 0**	**3**
5		CT-309	Computational Methods for Chemical Engineers	PCC-16	B	4 – 0 – 0	4
6			**Elective - I**	**PEC-1**	**B**	**3 – 0 – 0**	**3**
		MOOCs – 4	**Equivalent course from *MOOCs/Swayam#***				
7		CT-351	Chemical Reaction Engineering Lab	SEC-7	B	0 – 0 – 3	2
8		CT-353	Chemical Process Control Lab	SEC-8	B	0 – 0 – 3	2
9		CT-355	Computational Methods for Chemical Engineers Lab	SEC-9	B	0 – 0 – 3	2
10		CT-357	Summer Training / Summer Project##	AEC-5	B	0 – 0 – 0	2
			Total			**28**	**27**

The student should undergo summer training/project for a minimum period of four weeks during the summer vacation (between 4th & 5th semester). Own school or reputed academic/research institution within the country (IISc/IITs/NITs/IISERs and CSIRs) or university abroad is also permitted instead of industrial training.

To be evaluated at seventh semester based on assessing the report and seminar presentations.

Elective-I (PEC-1) List:

Sl.	Paper ID	Course Code	Course Name
1		CT-311	Fundamentals of Polymer Engineering
2		CT-313	Air Pollution Control Engineering
3		CT-315	Alternative Energy Sources
4		CT-317	Upstream Processing for Bioprocesses

SIXTH SEMESTER

Sl.	Paper ID	Course Code	Course Name	Category Code	Type: Basic (B)/ Honours (H)	Contact L – T - P	Credits
1		CT-302	Transport Phenomena	PCC-17	B	4 – 0 – 0	4
2		CT-304	Process Modelling & Simulation	PCC-18	B	4 – 0 – 0	4
3		CT-306	Process Equipment Design	PCC-19	B	4 – 0 – 0	4
4		CT-308	Fuels and Combustion	PCC-20	B	3 – 0 – 0	3
5			**Elective - II**	**PEC-2**	**B**	**3 – 0 – 0**	**3**
		MOOCs – 5	**Equivalent course from *MOOCs/Swayam#***				
6		CT-352	Fuel Technology Lab	SEC-10	B	0 – 0 – 3	2
7		CT-354	Process Modelling & Simulation Lab	SEC-11	B	0 – 0 – 3	2
8		CT-356	Seminar-II	AEC-6	B	0 – 0 – 3	2
			Total			**27**	**24**

Elective-II (PEC-2) List:

Sl.	Paper ID	Course Code	Course Name
1		CT-310	Multiphase Reactor
2		CT-312	Water Pollution and Abatement
3		CT-314	Energy Audit for Process Industries
4		CT-316	Biological Reactors

Fourth Year

SEVENTH SEMESTER

Sl.	Paper ID	Course Code	Course Name	Category Code	Type: Basic (B)/ Honours (H)	Contact L – T - P	Credits
1		CT-401	Mathematical Methods in Chemical Engineering	PCC-21	H	4 – 0 – 0	4
2		CT-403	Chemical Process Safety & Risk Management	PCC-22	H	4 – 0 – 0	4
3		CT-405	Chemical Process Engineering and Economics	PCC-23	H	4 – 0 – 0	4
4			Elective - III	PEC-3	B	3 – 0 – 0	3
		MOOCs – 6	Equivalent course from *MOOCs/Swayam#*				
5			Elective – IV	PEC-4	B	3 – 0 – 0	3
		MOOCs – 7	Equivalent course from *MOOCs/Swayam#*				
6		CT-451	Summer Training/Project##	SEC-12	B	0 – 0 – 0	2
7		CT-453	Minor Project	PW-1	B	0 – 0 – 12	6
			Total			**30**	**26**

The student should undergo summer training/project for a minimum period of four weeks during the summer vacation (between 6th & 7th semester). Own school or reputed academic/research institution within the country (IISc/IITs/NITs/IISERs and CSIRs) or university abroad is also permitted instead of industrial training.

To be evaluated at seventh semester based on assessing the report and seminar presentations.

Elective-III (PEC-3) List:

Sl.	Paper ID	Course Code	Course Name
1		CT-407	Statistical Analysis of Process Data
2		CT-409	Solid Waste Management
3		CT-411	Hydrogen and Fuel Cell
4		CT-413	Industrial Biotechnology

Elective-IV (PEC-4) List:

Sl.	Paper ID	Course Code	Course Name
1		CT-415	Introduction to Computational Fluid Dynamics
2		CT-417	Environmental Impact Assessment
3		CT-419	Biosensor and Diagnostic Devices for Healthcare Applications
4		CT-421	Biochemical Processes

EIGHTH SEMESTER

Sl.	Paper ID	Course Code	Course Name	Category Code	Type: Basic (B)/ Honours (H)	Contact L – T - P	Credits
1		CT-402	Industrial Pollution Control	PCC-24	B	3– 0 – 0	3
2		CT-404	Introduction to Biochemical Engineering	PCC-25	B	4 – 0 – 0	4
3		CT-406	Analytical Methods in Engineering	PCC-26	B	3– 0 – 0	3
4		CT-408	Chemical Process Optimization	PCC-27	H	4 – 0 – 0	4
5		CT-450	Analytical Methods in Engineering Lab	PCC-28	B	0 – 0 – 3	2
6		CT-452	Major Project	PW-2	B	0 – 0 – 24	12
			Total			**41**	**28**

- **#Registration fees for the MOOCS/SWAYAM courses will be borne by the students.**

CRITERION FOR INTERNSHIP IN LIEU OF PROJECT WORK

"Students who choose to complete the credit requirements for the award of the B.Tech degree through internship shall not be eligible for the B.Tech (With Research) in Chemical Engineering or B.Tech (Honours with Research) in Chemical Engineering degrees. ***Such students shall be awarded the B.Tech in Chemical Engineering degree only.****"*

1. **Internship Option:**
   Students are permitted to undertake an internship in place of the regular project work component in the curriculum.

2. **Eligibility:**
   Only students selected through on-campus placement drives are eligible to opt for:
   - A **full-year internship** (covering both the 7th and 8th semesters), or
   - A **six-month internship** (during the 8th semester only),
     in reputed chemical or allied industries.

3. **Credit Equivalence:**
   Student approved for internship will be **exempted from Minor Project (CT-453) and/or Major Project (CT-450)**. The academic credits earned through the internship will be considered equivalent to the project credits for the respective semester(s).

4. **Industry Supervision and Reporting:**
   The host industry shall provide a **monthly progress/performance report** directly to the **Dean, University School of Chemical Technology**.

5. **Completion and Evaluation:**
   Upon successful completion of the internship, the industry shall issue a:
   - **Completion Certificate**, and
   - **Evaluation Sheet** rating the student's performance on a **100-point scale**.

6. **Premature Withdrawal from Internship:**
   If a student **discontinues the internship mid-semester** for any reason, a **project supervisor** will be assigned by the school. The student must then complete the required project work to fulfil degree requirements.
   - In such cases, the **final assessment** will be based on the **cumulative performance** in both the internship and the subsequent project work.

SYLLABUS

FIRST SEMESTER

Sl.	Paper ID	Course Code	Course Name	Category Code	Basic / Honours	Contact L – T - P	Credits
1		BS-115	Engineering Chemistry-I	BSC-1	B	3 – 0 – 0	3
2		BS-117	Engineering Mathematics –I	BSC-2	B	3 – 0 - 0	3
3		BS-119	Engineering Physics - I	BSC-3	B	2– 0 – 0	2
4		IT-101	Programming for Problem Solving	AEC-1	B	3 – 0 – 0	3
5		IT-107	Engineering Mechanics	ESC-1	B	3 – 0 – 0	3
6		CT-101	Fundamentals of Chemical Engineering	PCC-1	B	2 – 0 – 0	2
7		CT-103	Environment and Safety Engineering*	VAC-1*	B	2 – 0 – 0	2
8			**Multidisciplinary course (To be opted among the offered electives from other discipline)**	**MDC-1$**	**B**	**3 – 0 – 0**	**3**
9		IT-151	Programming for Problem Solving Lab	SEC-1	B	0 – 0 – 2	1
10		BS-161	Engineering Chemistry Lab	BSC-4	B	0 – 0 – 2	1
11		BS-163	Engineering Physics Lab - I	BSC-5	B	0 – 0 – 2	1
			Total			**27**	**24**

BS-115	Engineering Chemistry – I	L-T-P: 3-0-0	3 Credits	BSC-1

Pre-requisites: None

COURSE OBJECTIVES

1. To introduce fundamental concepts in atomic structure, bonding, and molecular properties.
2. To understand the thermochemical and kinetic aspects of chemical reactions.
3. To build a conceptual foundation in surface chemistry applicable to Chemical Engineering.
4. To enhance experimental skills through hands-on laboratory sessions.

COURSE OUTCOMES

After completion of the course students will be able to:

1. Apply quantum mechanical principles to atomic structure and explain chemical bonding.
2. Analyze thermochemical processes and reaction kinetics with appropriate models.
3. Explain reactivity and stability of organic molecules based on electronic effects.
4. Describe and analyze surface phenomena, colloids, and nanodispersions.

COURSE CONTENT

UNIT 1: Atomic Structure & Chemical Bonding **(12 Hrs)**

Introduction to wave mechanics, the Schrödinger equation as applied to hydrogen atom, origin of quantum numbers, Long form of periodic table on the basis of Electronic configuration s, p, d, f block elements periodic trends, Ionization potential, atomic and ionic radii electron affinity &electro-negativity.

Chemical Bonding: Ionic bond, energy changes, lattice energy Born Haber Cycle, Covalent bond-energy changes, Potential energy curve for H_2 molecule, characteristics of covalent compound, co-ordinate bond- Werner's Theory, effective atomic numbers, hybridization and resonance, Valence Shell Electron Repulsion theory (VSEPR), Discussion of structures of H_2O, NH_3, BrF_3, SiF_4, Molecular orbital theory, Linear combination of atomic orbitals (LCAO) method. Structure of simple homo nuclear diatomic molecule like H_2, N_2, O_2, F_2.

UNIT 2: First law of Thermodynamics and Thermochemistry **(10 Hrs)**

1st Law of thermodynamics, types of systems, intensive and extensive variables, Work done in the expansion of an ideal gas under isothermal & adiabatic conditions , enthalpy, enthalpy for phase change, heat capacity of a system.Hess's Law, heat of reaction, effect of temperature on heat of reaction at constant pressure (Kirchhoff's Equation) heat to dilution, heat of hydration, heat of neutralization and heat of combustion, Flame temperature.

UNIT 3: Chemical Kinetics **(10Hrs)**

Significance of rate law and rate equations, order and molecularity, Determinations of order of simple reactions-experimental method, Equilibrium constant and reaction rates -Lindermann, collision and activated complex theories, characteristics of consecutive, reversible and parallel reactions – Steady state and non-steady state approach.

UNIT 4: Surface Chemistry **(10 Hrs)**

Adsorption of gases by solids, thermodynamics of adsorption, Freundlich, Langmuir and BET(no derivation) adsorption isotherms, Adsorption from solution- Gibbs adsorption isotherm(derivation included) & surface excess concentration, Surface tension, surface energy, flat and curve surface, pressure differential across a curved surface and capillary rise and fall, Kelvin equation, influence of soap molecules on surface tension, micro heterogeneous systems and their uses (micelles, emulsions, microemulsions with reference to the basis of their formation, vesicles and lipozomes). Contact angle, wetting, spreading and adhesion.

TEXT AND REFERENCES BOOKS

1. Nagarajan, E. R., and Ramalingam, S. *Engineering Chemistry*, Wiley, 2017.
2. Lee, J. D. Concise *Inorganic Chemistry*. 5th Edition, Oxford University Press, 2008, ISBN: 978-8126515547.
3. Atkins, P. W. Physical Chemistry. 9th Edition, Oxford University Press, 2010, ISBN: 978-1-429-21812-2.
4. Puri, B. R., Sharma, L. R., & Pathania, M. S. Principles of Physical Chemistry. 47th Edition, Vishal Publishing Co., 2017.
5. Holmberg, K., Jönsson, B., Kronberg, B., & Lindman, B. Surfactants and Polymers in Aqueous Solution. 2nd Edition, John.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	3	3	2	-	-	-	1	1	-	1
CO2	2	2	3	3	2	-	-	-	1	1	-	1
CO3	2	2	3	3	2	-	-	-	1	1	-	1
CO4	2	2	3	3	2	-	-	-	1	1	-	1

BS-117	Engineering Mathematics – I	L-T-P: 3-0-0	3 Credits	BSC-2

Pre-requisites: None

COURSE OBJECTIVES

1. To introduce the concepts of multivariable calculus and their engineering applications.
2. To build a foundation in solving ordinary differential equations (ODEs) and using them for mathematical modelling.
3. To understand linear algebra concepts and apply them to engineering problems.
4. To develop a strong grasp of vector calculus and its physical interpretation through integral theorems.

COURSE OUTCOMES

After completion of the course students will be able to:

1. Apply partial derivatives and optimization techniques to multivariable functions in engineering problems.
2. Solve and analyze ordinary differential equations and use special functions for modelling real-world systems.
3. Perform matrix operations, solve linear systems, and compute eigenvalues/eigenvectors for engineering applications.
4. Use vector calculus and apply integral theorems in engineering problems.

COURSE CONTENT

UNIT 1: Multivariable Calculus and Coordinate Transformation (10Hrs)

Partial Derivatives and Chain Rule; Differentiation of Implicit Functions; Exact Differentials and Its Applications; Maxima, Minima, and Saddle Points; Method of Lagrange Multipliers; Differentiation under the Integral Sign (Leibniz Rule); Jacobians, Change of Variables, and Coordinate Transformations.

UNIT 2: Ordinary Differential Equations and Special Functions (12 Hrs)

Basic Concepts; Geometric Meaning of $y' = f(x, y)$; Direction Fields, Euler's Method; Separable, Exact and Linear ODEs; Bernoulli Equation, Integrating Factors; Population Dynamics, Orthogonal Trajectories; Homogeneous Linear ODEs with Constant Coefficients; Differential Operators; Euler–Cauchy Equations, Modelling of Free Oscillations of a Mass–Spring System; Wronskian and Linear Independence; Nonhomogeneous ODEs, Solution by Variation of Parameters; Power Series Solutions, Legendre's Equation and Polynomials; Bessel's Equation, Bessels's functions $J_n(x)$ and $Y_n(x)$; Gamma Function.

UNIT 3: Linear Algebra and Matrix Computations (10 Hrs)

Matrices and Determinants, Gauss Elimination; Matrix Rank, Linear Independence, Vector Spaces; Solutions of Linear Systems and concept of Existence, Uniqueness, Determinants; Cramer's Rule, Gauss– Jordan Elimination; Eigenvalues and Eigenvectors; Characteristic Equation; Diagonalization and Cayley–Hamilton Theorem, Quadratic Forms; Positive Definiteness, Special Matrices: Symmetric, Skew-Symmetric, Orthogonal.

UNIT 4: Vector Calculus and Integral Theorems (10 Hrs)

Vector and Scalar Functions and Their Fields; Derivatives, Curves; Arc Length; Curvature; Torsion, Gradient of a Scalar Field; Directional Derivative, Divergence of a Vector Field, Curl of a Vector Field, Line Integrals, Path Independence of Line Integrals, Double Integrals, Green's Theorem in the Plane, Surfaces for Surface Integrals, Surface Integrals, Triple Integrals, Stokes Theorem. Divergence Theorem of Gauss.

TEXT AND REFERENCES BOOKS

1. Kreyszig, E., *Advanced Engineering Mathematics*, 10th Edition, John Wiley & Sons, 2011.
2. Riley, K.F., Hobson, M.P. and Bence, S.J., *Mathematical Methods for Physics and Engineering*, Cambridge University Press, 2013.
3. Stroud, K.A. and Booth, D.J., *Engineering Mathematics*, Macmillan Education, 2020.
4. Turyn, L., *Advanced Engineering Mathematics*, Taylor & Francis, 2014.
5. Zill, D.G., *Advanced Engineering Mathematics*, Jones & Bartlett Learning, 2018.
6. Duffy, D.G., *Advanced Engineering Mathematics with MATLAB*, Taylor & Francis, 2017.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	2	3	3	3	1	-	-	-	-	-	1	2
CO2	2	3	3	3	1	-	-	-	-	-	2	2
CO3	2	3	3	3	1	-	-	-	-	-	2	2
CO4	2	3	3	3	1	-	-	-	-	-	2	2

BS-119	Engineering Physics – I	L-T-P: 2-0-0	2 Credits	BSC-3

Pre-requisites: None

COURSE OBJECTIVES

1. To understand the fundamentals of coherence and interference.
2. To understand Fraunhofer diffraction.
3. To enable studying polarization and applications.
4. To study laser light and different lasers.

COURSE OUTCOMES (COs)

1. After completion of the course students will be able to:
2. Understand the principles of wave optics including interference and coherence
3. Analyze diffraction patterns and understand resolving power in optical systems.
4. Explain the phenomena of polarization and its applications in optical instrumentation.
5. Describe the working principles of different types of lasers and their applications

COURSE CONTENT

UNIT 1: Interference of Light (7Hrs)

Introduction to Interference: The wave nature of light: spatial and temporal coherence, coherence length & time; Interference by division of wave front; Young's double slit experiment; Interference by division of amplitude: Newton's rings.

UNIT 2: Diffraction (7Hrs)

Introduction to diffraction: Fraunhofer diffraction: single slit, N-slit: diffraction grating, resolving power and Rayleigh criterion, dispersive power; Optical instruments and fundamental limits due to diffraction.

UNIT 3: Polarization (7Hrs)

Introduction to polarization of light: plane, circular and elliptically polarized light; Double refraction, Nicol prism, quarter and half wave plates, optical activity: specific rotation and Laurent Half Shade Polarimeter.

UNIT 4: Lasers (7Hrs)

Properties of Laser light; Concept of Laser: Einstein coefficients A & B (Qualitative), Light-matter interaction: Absorption, Spontaneous and Stimulated emission; Population Inversion, two-level lasers, three-level lasers, four-level lasers examples: Ruby Laser, Helium-Neon Laser.

TEXT AND REFERENCES BOOKS

1. Ghatak, A., *Optics*, 4thEdition, McGraw Hill Companies, 2009.
2. Subrahmanyam, N., Lal, B. and Avadhanulu, M.N., *Optics*, 25thEdition, S. Chand, 2012.
3. Sharma, K.K., *Optics: Principles and Applications*, 1stEdition, Elsevier, 2006.
4. Jenkins, F.A. and White, H.E., *Fundamentals of Optics*, 4thEdition, McGraw Hill, 2001.
5. Pavia, D.L., Lampman, G.M., Kriz, G.A. and Vyvyan, J.R., *Introduction to Spectroscopy*, 5thEdition, Cengage Learning, 2015.
6. Larkin, P., *Infrared and Raman Spectroscopy: Principles and Spectral Interpretation*, 1stEdition, Elsevier, 2011.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	2	3	-	-	-	-	-	-	-	-	1
CO2	3	2	3	-	-	-	-	-	-	-	-	1
CO3	2	2	3	-	-	-	-	-	-	-	-	1
CO4	2	3	3	2	-	-	-	-	1	1	-	1

IT-101	Programming for Problem Solving	L-T-P: 3-0-0	3 Credits	AEC-1

Pre-requisites: None

COURSE OBJECTIVES

1. To impart basic knowledge about simple algorithms for arithmetic and logical problems so that students can understand how to write a program, syntax and logical errors in 'C'.
2. To impart knowledge about how to implement conditional branching, iteration and recursion in 'C'.
3. To impart knowledge about using arrays, pointers, files, union and structures to develop algorithms and programs in 'C'.
4. To impart knowledge about how to approach for dividing a problem into sub-problems and solve the problem in 'C'

COURSE OUTCOMES

After completion of the course students will be able to:

1. Develop simple algorithms for arithmetic and logical problems and implement them in 'C'.
2. Implement conditional branching, iteration and recursion and functions in 'C'
3. Use arrays, pointers, union and structures to develop algorithms and programs in 'C'
4. Decompose a problem into functions and synthesize a complete program using divide and conquer approach in 'C'.

COURSE CONTENT

UNIT 1: Introduction to Programming **(10 Hrs)**

Computer system, components of a computer system, computing environments, computer languages, creating and running programs, Preprocessor, Compilation process, role of linker, idea of invocation and execution of a programme. Algorithms: Representation using flowcharts, pseudocode. **Introduction to C language:** History of C, basic structure of C programs, process of compiling and running a C program, C tokens, keywords, identifiers, constants, strings, special symbols, variables, data types, I/O statements. Inter conversion of variables. **Operators and expressions:** Operators, arithmetic, relational and logical, assignment operators, increment and decrement operators, bitwise and conditional operators, special operators, operator precedence and associativity, evaluation of expressions, type conversions in expressions.

UNIT 2: Control Structures **(10 Hrs)**

Decision statements; if and switch statement; Loop control statements: while, for and do while loops, jump statements, break, continue, go to statements. **Arrays:** Concepts, One-dimensional array, declaration and initialization of one-dimensional arrays, two dimensional arrays, initialization and accessing, multi-dimensional arrays. **Functions:** User defined and built-in Functions, storage classes, Parameter passing in functions, call by value, **Passing arrays to functions:** idea of call by reference, Recursion. **Strings:** Arrays of characters, variable length character strings, inputting character strings, character, library functions, string handling functions.

UNIT 3: Pointers: **(10 Hrs)**

Pointer basics, pointer arithmetic, pointers to pointers, generic pointers, array of pointers, functions returning pointers, Dynamic memory allocation. Pointers to functions. Pointers and Strings. **Structures and unions:** Structure definition, initialization, accessing structures, nested structures, arrays of structures, structures and functions, self-referential structures, unions, typedef, enumerations. **File handling:** command line arguments, File modes, basic file operations read, write and append. Scope and life of variables, multi-file programming.

UNIT 4: Basic Algorithms **(12 Hrs)**

Finding Factorial, Fibonacci series, Searching, Basic Sorting Algorithms- Bubble sort, Insertion sort and Selection sort. Find the square root of a number, array order reversal, reversal of a string, two-way merge sort, stacks, queues, single –link linked list, Binary search tree.

TEXT AND REFERENCES BOOKS

1. Dromey, R.G., *How to Solve It by Computer*, Prentice-Hall India, EEE Series, 1982.
2. Kernighan, B.W. and Ritchie, D.M., *The C Programming Language*, Pearson Education, 1988.
3. Gaddis, T., *Programming Logic and Design*, 2nd Edition, Pearson, 2016.
4. Hanly, J.R. and Koffman, E.B., *Problem Solving and Program Design in C*, Pearson, 2016.
5. Felleisen, M., Findler, R.B., Flatt, M. and Krishnamurthi, S., *How to Design Programs*, MIT Press, 2018.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	2	1	1	-	-	-	2	1	1	3
CO2	3	3	2	1	1	-	-	-	2	1	1	3
CO3	3	3	3	1	1	-	-	-	2	1	1	3
CO4	3	3	3	1	1	-	-	-	2	1	1	3

IT-107	Engineering Mechanics	L-T-P: 3-0-0	3 Credits	ESC-1

Pre-requisites: None

COURSE OBJECTIVES

1. To impart knowledge to solve problems pertaining to force systems, equilibrium and distributed systems.
2. To impart knowledge to solve problems of friction and engineering trusses.
3. To impart knowledge to deal with the problems of kinematics and kinetics of particle
4. To impart knowledge to deal with the problems of kinematics and kinetics of rigid bodies.

COURSE OUTCOMES

After completion of the course students will be able to:

1. Ability to solve problems pertaining to force systems, equilibrium and distributed systems.
2. Ability to solve problems of friction and engineering trusses.
3. Ability to deal with the problems of kinematics and kinetics of particle
4. Ability to deal with the problems of kinematics and kinetics of rigid bodies.

COURSE CONTENT

UNIT 1: Force Systems and Equilibrium **(10 Hrs)**

Force System: Introduction, force, principle of transmissibility of force, resultant of a force system, resolution of a force, moment of force about a line, Varigon's theorem, couple, resolution of force into force and a couple, properties of couple and their application to engineering problems.

Equilibrium: Force body diagram, equations of equilibrium and their applications to engineering problems, equilibrium of two force and three force members.

Distributed Forces: Determination of center of gravity, center of mass and centroid by direct integration and by the method of composite bodies, mass moment of inertia and area moment of inertia by direct integration and composite bodies method, radius of gyration, parallel axis theorem, polar moment of inertial.

UNIT 2: Structures and Friction **(10 Hrs)**

Structure: Plane truss, perfect and imperfect truss, assumption in the truss analysis, analysis of perfect plane trusses by the method of joints, method of section and graphical method.

Friction: Static and Kinetic friction, laws of dry friction, co-efficient of friction, angle of friction, angle of repose, cone of friction, frictional lock, friction in flat pivot and collar bearing, friction in flat belts.

UNIT 3: Dynamics of Particles **(10 Hrs)**

Kinematics: Rectilinear motion, plane curvilinear motion, rectangular coordinates, normal and tangential coordinates.

Kinetics: Equation of motion, rectilinear motion and curvilinear motion, work-energy equation, conservation of energy, concept of impulse and momentum, conservation of momentum, impact of bodies, co- efficient of restitution, loss of energy during impact.

UNIT 4: Dynamics of Rigid Bodies and Beams **(12 Hrs)**

Kinematics of Rigid Bodies: Concept of rigid body, types of rigid body motion, absolute motion, introduction to relative velocity, relative acceleration (Corioli's component excluded) and instantaneous center of zero velocity, Velocity and acceleration.

Kinetics of Rigid Bodies: Equation of motion, translatory motion and fixed axis rotation, application of work energy principles to rigid bodies conservation of energy.

Beams: Introduction, types of loading, methods for the reactions of a beam, space diagram, types of end supports, beams subjected to couple.

TEXT AND REFERENCES BOOKS

1. Tayal, A.K., *Engineering Mechanics*, 14th Edition, Umesh Publications, 2010.
2. Kumar, K.L., *Engineering Mechanics*, 4th Edition, Tata McGraw-Hill, 2011.
3. Timoshenko, S., Young, D.H. and Rao, J.V., *Engineering Mechanics*, 5th Edition, Tata McGraw-Hill, 2017.
4. Shames, I.H., *Engineering Mechanics – Statics and Dynamics*, 4th Edition, PHI Learning, 2006.
5. Bhattacharya, B., *Engineering Mechanics*, 1st Edition, Oxford University Press, 2009.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	3	3	2	-	-	-	1	1	1	2
CO2	3	3	3	3	2	-	-	-	1	1	1	2
CO3	3	3	3	3	2	-	-	-	1	1	1	2
CO4	3	3	3	3	2	-	-	-	1	1	1	2

CT-101	Fundamentals of Chemical Engineering	L-T-P: 2-0-0	2 Credits	PCC-1

Pre-requisites: None

COURSE OBJECTIVES

1. To introduce the discipline of Chemical Engineering and its societal, industrial, and environmental roles.
2. To expose students to fundamental concepts and unit operations used in chemical industries.
3. To create awareness of major industrial processes and energy-material transformations.
4. To stimulate interest in core Chemical Engineering domains through real-life examples

COURSE OUTCOMES

After completion of the course students will be able to:

1. Describe the scope, history, and key domains of Chemical Engineering.
2. Identify common unit operations and their significance in chemical industries.
3. Explain basic industrial chemical processes and types of chemical reactors.
4. Describe the importance of mechanical operations like size reduction in industries.

COURSE CONTENT

UNIT 1: Introduction and Overview of Chemical Engineering (05 Hrs)

What is Chemical Engineering? Difference from Chemistry; Historical development and key milestones (e.g., George E. Davis, Haber-Bosch process); Scope and interdisciplinary nature (Chemistry, Physics, Math, Biology, Computing); Career paths: industry, research, environment, energy, pharmaceuticals, and more; Overview of core subjects: Heat Transfer, Mass Transfer, Thermodynamics, Fluid Mechanics, Reaction Engineering, Process Control, Mechanical Operations.

UNIT 2: Unit Operations in Chemical Engineering (05 Hrs)

Concept of a process and unit operation; Classification: Fluid flow, Heat transfer, Mass transfer, Mechanical operations; Real-life applications: distillation, absorption, filtration, drying, evaporation; Role of unit operations in process design and chemical plants.

UNIT 3: Industrial Chemical Reactions and Reactors (10 Hrs)

Overview of industrial chemical processes: N**itration** (e.g., nitrobenzene production), **Hydrogenation** (e.g., edible oils, aniline), **Polymerization** (e.g., plastics), **Combustion** and **fermentation;** Types of chemical reactors: Batch, CSTR, PFR (qualitative intro); Importance of yield, conversion, selectivity, rate of reaction; Examples from fertilizer, petrochemical, and polymer industries.

UNIT 4: Mechanical Operations and Particle Size Reduction (08 Hrs)

Importance of size reduction in solids processing (e.g., cement, coal, pharmaceuticals); Types of equipment: crushers, grinders, ball mills, fluid energy mills; Size classification and screening; Introduction to energy requirements and basic efficiency; Real-world link: cement, food processing, paint, and mining industries.

TEXT AND REFERENCE BOOKS

1. Badger, W.L. and Banchero, J.T., *Introduction to Chemical Engineering*, 1st Edition, McGraw-Hill, 1955.
2. Felder, R.M. and Rousseau, R.W., *Elementary Principles of Chemical Processes*, 4thEdition, Wiley, 2020.
3. Ghoshal, S.K., Sanyal, S.K. and Datta, S., *Introduction to Chemical Engineering*, Tata McGraw-Hill, New Delhi, 2006.
4. Himmelblau, D.M. and Riggs, J.B., *Basic Principles and Calculations in Chemical Engineering*, 8thEdition, Pearson, 2012.
5. Levenspiel, O., *Chemical Reaction Engineering*, 3rdEdition, Wiley, 1999.
6. McCabe, W.L., Smith, J.C. and Harriott, P., *Unit Operations of Chemical Engineering*, 7thEdition, McGraw-Hill, 2005.
7. Turton, R., Shaeiwitz, J.A., Bhattacharyya, D. and Whiting, W.B., *Analysis, Synthesis, and Design of Chemical Processes*, 5thEdition, Pearson, 2021.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	-	-	-	2	2	-	-	2	-	3
CO2	3	2	2	-	-	-	-	-	-	-	-	-
CO3	3	2	2	-	-	-	-	-	-	-	-	-
CO4	3	2	2	-	-	-	-	-	-	-	-	-

CT-103	Environment and Safety Engineering	L-T-P: 2-0-0	2 Credits	VAC-1

Pre-requisites: Nil

COURSE OBJECTIVES

To develop understanding of environmental protection and safety measures in chemical industries with an emphasis on pollution control, risk assessment, and regulatory compliance.

COURSE OUTCOMES

1. Identify major environmental pollutants and explain their impact on ecosystems and human health.
2. Understand environmental laws and apply pollution prevention techniques.
3. Analyze risks and hazards in chemical process industries.
4. Implement industrial safety protocols and design systems for accident prevention.

COURSE CONTENT

UNIT 1: Environmental Pollution and Control (07 Hrs)

Types of pollution—air, water, and soil—with emphasis on sources, effects, and control strategies; BOD, COD, suspended solids, particulate matter, and gaseous emissions; Waste minimization, segregation, and recycling. Fundamental treatment methods including primary, secondary, and tertiary treatments for effluent and flue gas cleaning.

UNIT 2: Environmental Impact and Legislation (07 Hrs)

Environmental impact assessment (EIA), environmental auditing, and life cycle assessment (LCA). National and international environmental legislation such as the Water Act, Air Act, and Environment Protection Act. The role of organizations like CPCB and SPCBs, ISO 14000, and the role of regulatory compliance in chemical industries.

UNIT 3: Fundamentals of Industrial Safety (04 Hrs)

Accident statistic:, Fatal Accident Rate, OSHA incidence rate, fatality rate, Industrial Hygiene: evaluation, monitoring and control, Material safety data sheet (MCDS), Threshold Limit Value (TLV), Time Weight Average (TWA).

UNIT 4: Basics of Fire and Explosion Hazards (06 Hrs)

Distinguish between fire and explosion, fire triangle, Flash point, fire point, auto-ignition temperature, Flammability limits, Fire protection measures.

TEXT AND REFERENCE BOOKS

1. Elements of environmental sciences & engineering, P. Meenakshi, PHI Learning Pvt Ltd, 2014.
2. Chemical Process Safety Fundamentals with Applications, Daniel A Crowl, Joseph F. Louvar, 3rd Edition, Prentice Hall, 2013.
3. Environmental Engineering and safety, Sangeeta Raut, Sudip Kumar Sen, Scientific Publisher, Jodhpur, 2017
4. Introduction To Environmental Science, Y. Anjaneyulu, B.S. Publications, Hyderabad, 2020

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	3	2	1	3	2	1	3	1	1	3
CO2	3	3	3	2	1	3	2	1	3	1	1	3
CO3	3	3	3	2	1	3	2	1	3	1	1	3
CO4	3	3	3	2	1	1	2	1	1	1	1	3

IT-151	Programming for Problem Solving Lab	L-T-P: 0-0-2	1 Credits	SEC-1

Pre-requisites: IT-101

COURSE OBJECTIVES

1. To introduce students to the basic concepts of programming using C.
2. To develop problem-solving and logical thinking abilities.
3. To apply programming knowledge in solving real-world problems relevant to chemical engineering.
4. To provide hands-on practice in implementing algorithms and debugging codes.

COURSE OUTCOMES

After completion of the course students will be able to:

1. Apply basic programming constructs like loops, conditional statements, and arrays in solving problems.
2. Develop modular programs using functions and recursion.
3. Demonstrate understanding of pointers, file operations, and data handling.
4. Apply programming logic to solve basic chemical engineering problems and perform simulations.

LIST OF EXPERIMENTS

1. Write a program to display "Hello World!"
2. Write a program to perform addition, subtraction, multiplication, and division of two numbers.
3. Write a program to find whether a number is even or odd.
4. Write a program to compute factorial of a number using loops.
5. Write a program to find the greatest of three numbers.
6. Write a program to implement a calculator using switch-case.
7. Write a program to print Fibonacci series up to n terms.
8. Write a program to reverse a given integer.
9. Write a program to sort an array in ascending and descending order.
10. Write a program to find the sum and average of elements in an array.
11. Write a program to find transpose of a matrix.
12. Write a program to implement linear search and binary search.
13. Write a program using functions for temperature unit conversions.
14. Write a program to use pointer variables and pointer arithmetic.
15. Write a program to read and write data to a file.
16. Simple case studies related to Chemical Engineering (e.g., molar mass calculation, enthalpy, concentration).

TEXT AND REFERENCES BOOKS

1. Balagurusamy, E., *Programming in ANSI C*, 8th Edition, McGraw Hill, 2019.
2. Gottfried, B., *Programming with C*, 3rd Edition, Schaum's Outline Series, McGraw Hill, 2010.
3. Kanetkar, Y., *Let Us C*, 17th Edition, BPB Publications, 2020.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	2	2		2	-	-	-	-	-	-	-
CO2	3	3	2	2	2	-	-	-	-	-	-	-
CO3	3	3	2		3	-	-	-	-	-	-	2
CO4	2	3	3	2	3	2	-	-	-	-	-	2

BS-161	Engineering Chemistry Lab	L-T-P: 0-0-2	1 Credits	BSC-4

INSTRUCTIONS

1. The course objectives and course outcomes are identical to that of BA119 (Engineering Physics) as this is the practical component of the corresponding theory paper.
2. The practical list shall be notified by the teacher in the first week of the class commencement under intimation to the office of the school in which the paper is being offered.

BS-163	Engineering Physics Lab - I	L-T-P: 0-0-2	1 Credits	BSC-5

INSTRUCTIONS

1. The course objectives and course outcomes are identical to that of BA119 (Engineering Physics) as this is the practical component of the corresponding theory paper.
2. The practical list shall be notified by the teacher in the first week of the class commencement under intimation to the office of the school in which the paper is being offered.

SECOND SEMESTER

Sl.	Paper ID	Course Code	Course Name	Category Code	Basic / Honours	Contact L – T - P	Credits
1		BS-112	Engineering Chemistry-II	BSC-6	B	3 – 0 – 0	3
2		BS-114	Engineering Mathematics –II	BSC-7	B	3 – 0 – 0	3
3		BS-116	Engineering Physics - II	BSC-8	B	2 – 0 – 0	2
4		HS-130	Communication Skills	AEC-2	B	2 – 0 – 0	2
5		CT-102	Chemical Process Calculation	PCC-2	B	3 – 0 – 0	3
6		IT-104	Basics of Electrical Engineering	ESC-2	B	3 – 0 – 0	3
7		**MOOCs – 1**	**The Science of Happiness and Wellbeing * (*MOOCs/Swayam#*)**	VAC-2*	B	2 – 0 – 0	2
		HVEE-114	Human Values and Ethics *				
8			Multidisciplinary course (To be opted among the offered electives from other discipline)	**MDC-2$**	**B**	**3 – 0 – 0**	**3**
9		CT-150	Workshop Technology	SEC-2	B	0 – 0 – 2	1
		IT-160	Programming in Python Lab				
10		IT-152	Engineering Graphics	SEC-3	B	0 – 0 – 2	1
		MOOCs – 2	**Engineering Drawing and Computer Graphics (*MOOCs/Swayam#*)**				
11		BS-162	Engineering Physics Lab - II	BSC-9	B	0 – 0 – 2	1
			Total			**27**	**24**

BS-112	Engineering Chemistry - II	L-T-P: 3-0-0	3 Credits	BSC-6

Pre-requisites: None

COURSE OBJECTIVES

1. To build foundational understanding in chemical and ionic equilibria.
2. To promote interdisciplinary applications of phase rule and electrochemistry in chemical and environmental systems.
3. To equip students with analytical skills needed for engineering and research.
4. To introduce green chemistry perspectives in understanding chemical systems.

COURSE OUTCOMES

After completion of the course students will be able to:

1. Analyze chemical and phase equilibria in multicomponent systems
2. Apply principles of colligative properties to determine molecular properties.
3. Interpret electrochemical cell reactions and perform EMF calculations.
4. Solve ionic equilibrium and electrolysis problems relevant to industrial processes.

COURSE CONTENT

UNIT 1: Colloidal Systems **(10Hrs)**

Lyophilic and Lyophobic colloids, Preparation & properties of colloidal solutions, Electrical properties and zeta potential, coagulation of colloids, determination of size of colloidal particles, surfactants, emulsions, and gels.

UNIT 2: Chemical Equilibrium and Phase Behavior **(10Hrs)**

Law of Mass Action, Reaction; Equilibrium Constants: Kp, Kc & Kx, Interpretation & Calculation; Le Chatelier's Principle: Qualitative Prediction of Effects of Disturbances; Heterogeneous equilibria.

Phase Rule: Pressure-temperature phase diagrams, Clausius-Clapeyron equation, phase rule,One Component Systems – Water/CO_2, Sulphur (enantiotropy); Immiscible liquids, upper and lower consolute temperatures,Eutectic Systems, freezing point curve for Ag-Cu system, two component system with a solid compound formation.

UNIT 3: Electrochemistry and EMF **(12Hrs)**

Electrolytic conductance - Faraday's Laws of electrolysis,Specific and Equivalent Conductance, Transference Number(conceptual), Kohlrausch's Law, absolute velocity of ions, degree of ionization and conductance, application of conductance (solubility of sparingly soluble salts, conductometric titrations), Debye-Huckel, Onsager relations (no derivations), concept of activity and activity coefficient.

Cells (reversible and irreversible cells), electromotive force, galvanic cells, hydrogen and calomel electrode, single electrode potential, sign convention of EMF, thermodynamics of electrode potentials, EMF and equilibrium constant,Nernst equation, electrochemicalseries, Numerical based on above concepts.

UNIT 4: Ionic Equilibrium and Electrolysis Applications **(10Hrs)**

Solubility Product, Precipitation Equilibria, Potentiometric pH Determination & Titration, Electrolysis: Mechanisms, Decomposition Potential, Overpotential (its measurement), electrolytic separation of metals, commercial cells, fuel cells.

TEXT AND REFERENCES BOOKS

1. Atkins, P.W., *Physical Chemistry*, 10thEdition, Oxford University Press, 2014.
2. Glasstone, S., *Thermodynamics for Chemists*, 1stEdition, Affiliated East-West Press, 1946.
3. Glasstone, S., *An Introduction to Electrochemistry*, 1st Edition, Read Books, 1942.
4. Rakshit, P.C., *Physical Chemistry*, 7thEdition, Sarat Book Distributor, 2016.
5. Barrow, G.M., *Physical Chemistry*, 5thEdition, Tata McGraw-Hill, 1988.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	2	2	2	1	2	-	-	-	1	-	2
CO2	3	3	2	2	2		-	-	-	1	-	2
CO3	3	3	3	3	2	1	-	-	-	1	1	3
CO4	3	3	3	3	3	2	1	-	1	2	2	3

BS-114	Engineering Mathematics - II	L-T-P: 3-0-0	3 Credits	BSC-7

Pre-requisites: None

COURSE OBJECTIVES

1. To impart a solid foundation in complex analysis and its applications to engineering problems.
2. To introduce integral transforms (Laplace and Fourier) and their role in solving differential equations.
3. To develop the ability to solve linear and nonlinear PDEs arising in engineering.
4. To understand conformal mapping techniques for modelling physical systems.

COURSE OUTCOMES

After completion of the course students will be able to:

1. Analyze functions of a complex variable using analytic techniques and contour integration.
2. Apply conformal mapping and residue calculus to solve physical and engineering problems.
3. Use Laplace and Fourier transforms to solve ODEs and boundary value problems.
4. Model and solve PDEs related to waves, heat, and Laplace equations using separation of variables.

COURSE CONTENT

UNIT 1: Complex Analysis – I **(10 Hrs)**

Complex numbers: Geometric representation, polar form, powers and roots; Analytic functions and Cauchy–Riemann equations; Laplace's equation in complex form; Elementary functions: exponential, trigonometric, hyperbolic; Euler's formula, de Moivre's theorem (without proof), logarithmic functions; Singularities, zeros, concept of infinity; Contour integration: line integrals, Cauchy's integral theorem and formula; Taylor and Maclaurin series for analytic functions.

UNIT 2: Complex Analysis – II **(10 Hrs)**

Laurent series and classification of singularities; Residue theorem and applications to real integrals; Conformal mapping: concept and geometry of analytic functions; Möbius transformations and special cases; Applications of conformal mappings in electrostatics, heat conduction, and fluid flow; Poisson's integral formula for potential functions.

UNIT 3: Laplace & Fourier Transforms **(10 Hrs)**

Laplace Transforms: Definitions and existence (without proof), properties, First Shifting Theorem (s-Shifting), Transforms of Derivatives and Integrals and ODEs, Unit Step Function (Heaviside Function).Second Shifting Theorem (t-Shifting), Short Impulses. Dirac's Delta Function. Partial Fractions, Convolution. Integral Equations, Differentiation and Integration of Transforms. Solution of ODEs with Variable Coefficients, Solution of Systems of ODEs. Inverse Laplace transform and its properties.

Fourier Analysis: Fourier Series, Arbitrary Period. Even and Odd Functions. Half-Range Expansions, Sturm-Liouville Problems. Fourier Integral, Fourier Cosine and Sine Transforms, Fourier Transform. Usage of Fourier analysis for solution of ODEs. Inverse Fourier transform and its properties.

UNIT 4: Partial Differential Equations (PDEs) **(12Hrs)**

Basic Concepts of PDEs.

Modeling: Vibrating string – wave equation; Heat flow in solids – heat equation; Steady-state solutions – Laplace's equation.

Methods of Solution: Separation of variables, Fourier series method; D'Alembert's solution for wave equation; Solutions in rectangular and circular domains (polar and spherical coordinates); PDEs via Laplace and Fourier transforms.

TEXT AND REFERENCES BOOKS

1. Kreyszig, E., *Advanced Engineering Mathematics*, 10th Edition, John Wiley, 2011.
2. Stroud, K.A. and Booth, D.J., *Engineering Mathematics*, Macmillan, 2020.
3. Turyn, L., *Advanced Engineering Mathematics*, Taylor & Francis, 2014.
4. Zill, D.G., *Advanced Engineering Mathematics*, Jones & Bartlett Learning, 2018.
5. Duffy, D.G., *Advanced Engineering Mathematics with MATLAB*, Taylor & Francis, 2017.
6. Riley, K.F., Hobson, M.P. and Bence, S.J., *Mathematical Methods for Physics and Engineering*, Cambridge University Press, 2013.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3	3	3	1	-	-	-	-	-	1	2
CO2	2	3	3	3	1	-	-	-	-	-	2	2
CO3	2	3	3	3	1	-	-	-	-	-	2	2
CO4	2	3	3	3	1	-	-	-	-	-	2	2

BS-116	Engineering Physics - II	L-T-P: 2-0-0	2 Credits	BSC-8

Pre-requisites: None

COURSE OBJECTIVES

1. Understand the fundamentals of electric and magnetic fields and their relevance in chemical engineering.
2. To study Maxwell's equations to solve problems in electrostatics, magnetostatics, and electromagnetic wave propagation.
3. To comprehend the role of electromagnetic theory in chemical process instrumentation, sensors, and material characterization.
4. Studentswilllearnto aanalyze electromagnetic wave propagation in free space and materials.

COURSE OUTCOMES

After completion of the course students will be able to:

1. Learn to study the fundamentals of electric and magnetic fields and their relevance in chemical engineering.
2. Apply Maxwell's equations to solve problems in electrostatics, magnetostatics, and electromagnetic wave propagation.
3. Analyze the role of electromagnetic theory in chemical process instrumentation, sensors, and material characterization.
4. Analyze electromagnetic wave propagation in free space and materials.

COURSE CONTENT

UNIT 1: **(7Hrs)**

Vectors and operations: dot, and cross products; Cartesian, cylindrical, and spherical coordinates; Physical interpretations: Gradient, Divergence and Curl Theorems.

UNIT 2: **(7Hrs)**

Coulomb's law, electric field and potential, Gauss's law and applications, Dielectrics, polarization, and boundary conditions, Capacitance and energy storage. Biot-Savart law, Ampère's law; Magnetic fields due to currents, Magnetic materials and boundary conditions.

UNIT 3: **(7Hrs)**

Faraday's law of induction, Displacement current and Maxwell's equations (integral and differential forms), Physical meaning and chemical engineering applications (e.g., electromagnetic flowmeters, microwave heating).

UNIT 4: **(7Hrs)**

Wave equations for E and B fields, Plane wave solutions in free space, dielectrics, and conductors, Reflection, transmission, and absorption (microwave drying, dielectric heating), Introductory idea of Poynting vector and Theorem, Introductory idea of electromagnetic sensors for process control (conductivity probes), Material characterization using EM waves (dielectric properties), Safety aspects: EM exposure, shielding, and instrumentation standards.

TEXT AND REFERENCES BOOKS

1. Griffiths, D.J., *Introduction to Electrodynamics*, 3rd Edition, Pearson Education, 1999.
2. Jackson, J.D., *Classical Electrodynamics*, 3rd Edition, Wiley, 2010.
3. Sadiku, M.N.O., *Elements of Electromagnetics*, 3rd Edition, Oxford University Press, 2001.
4. Chow, T.L., *Introduction to Electromagnetic Theory*, Jones & Bartlett Learning, 2006.
5. Hayt, W.H. and Buck, J.A., *Engineering Electromagnetics*, 8th Edition, McGraw-Hill, 2011.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	2	1	2	-	-	-	1	-	2
CO2	3	3	2	2	2		-	-	-	1	-	2
CO3	3	3	3	3	2	1	-	-	-	1	1	3
CO4	3	3	3	3	3	2	1	-	1	2	2	3

HS -130	Communication Skills	L-T-P: 2-0-0	2 Credits	AEC-2

Pre-requisites: None

COURSE OBJECTIVES

To familiarize students with basic concepts of effective communication that will help them effectively convey their ideas and function efficiently in academic, professional, and social environments.

COURSE OUTCOMES

1. Ability to understand the basic structure of language.
2. Ability to communicate effectively in writing.
3. Ability to apply verbal and non-verbal communication skills in real-life situations.
4. Ability to effectively communicate in interpersonal and intercultural situations without being misunderstood.

COURSE CONTENT

UNIT 1 **(06 Hrs)**

Basic Language Efficiency 1: Parts of Speech, Sentence Structure, Subject-Verb Agreement, Vocabulary, Common Errors.
Basic Language Efficiency 2: Writing Skills: Types of Writing, Paragraph writing, Paraphrasing, Summarizing, Précis Writing.

UNIT 2 **(08 Hrs)**

Communication as Process: Concept of Communication, Communication as a Process, Formal, Informal and Intercultural communication, Barriers to Effective Communication and remedies, Characteristics of Effective Communication.
Communication Efficiency: Concept of Non-verbal Communication, Elements of Non-verbal Communication – Gestures, Postures, Facial-expressions, Gaze, Eye contact, and Space, Presentation skills – Interviews, Group Discussion, Making presentations with Audio-visual aids, Electronic Communication – Internet and Social media.

UNIT 3 **(07 Hrs)**

Formal Written Communication: Meetings – Agenda and Minutes, Press release, Letter writing, Notice, Memorandum, E-mails.

UNIT 4 **(07 Hrs)**

Technical Documents: Definition, Types, Structure, Significant Features of: Resume Writing, Report Writing, Proposal Writing, Dissertation, and Research Papers.

TEXT AND REFERENCE BOOKS

1. Fleddermann, C.B., *Engineering Ethics*, 4th Edition, Pearson, 2014.
2. Harris, C.E. and Rabins, M.J., *Engineering Ethics: Concepts and Cases*, 5thEdition, Cengage Learning, 2012.
3. Kiran, D.R., *Professional Ethics and Human Values*, 1stEdition, McGraw-Hill, 2014.
4. Martin, M.W. and Schinzinger, R., *Introduction to Engineering Ethics*, 2ndEdition, McGraw-Hill, 2010.
5. Naagarazan, R.S., *A Textbook on Professional Ethics and Human Values*, 2ndEdition, New Age Publishers, 2006.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	-	-	-	-	-	-	-	3	3	-	3
CO2	-	-	-	-	-	-	-	-	3	3	-	3
CO3	-	-	-	-	-	-	-	-	3	3	-	3
CO4	-	-	-	-	-	-	-	-	3	3	-	3

CT-102	Chemical Process Calculation	L-T-P: 3-0-0	3 Credits	PCC-2

Pre-requisites: None

COURSE OBJECTIVES

Course aims to teach fundamental principles and techniques to solve chemical engineering problems that involves mass and energy balance.

COURSE OUTCOMES

After completion of the course students will be able to:

1. Apply dimensional analysis and process variables in chemical calculations.
2. Perform material balances on non-reactive systems with recycle and bypass.
3. Solve material balances for reactive systems using stoichiometry and conversions.
4. Conduct energy balances for reactive and non-reactive processes, enthalpy and heat calculations.

COURSE CONTENT

UNIT 1: Introduction to Process Calculations (10 Hrs)

Unit conversions and dimensional homogeneity, dimensionless numbers and dimensional analysis. pressure, temperature, density, flow rates, mole and mass fractions, average molecular weight, chemical composition, ideal gas law, real gas behavior, Single-phase and multiphase systems.

UNIT 2: Material Balance on Non-Reactive Systems (12 Hrs)

Law of conservation of mass; General balance equation (differential and integral forms); Basis of calculation and scaling (scale-up and scale-down); Degrees of freedom analysis; concept of stoichiometry; mole balance and massbalance; recycle, bypass and purge operations in non-reactive systems.Material balance over unit operations: such as Distillation, Crystallization, Evaporation, Drying etc.

UNIT 3: Material Balance on Reactive System (10 Hrs)

Stoichiometry of chemical reactions; Limiting and excess reactants; Conversion, Yield, Selectivity; Extent of reaction and relation to conversion; Molecular and atomic balance to solve reactive systems; Degrees of freedom in reactive systems; Material balances with recycle and purge in reactive processes; Single-pass and overall conversion.

UNIT 4: Energy Balance (10 Hrs)

First law of thermodynamics for closed and open systems; Forms of energy: Internal, enthalpy, kinetic, potential; Heat capacity and enthalpy change with temperature and pressure; Enthalpy change in phase change, mixing, and solution; Standard heats of formation, reaction, and combustion; Energy balances in reactive and non-reactive systems; Estimation of calorific values and combustion calculations; Humidity and saturation, humid heat, Humiditychart and its applications; Use of steam tables and enthalpy-concentration charts.

TEXT AND REFERENCE BOOKS

1. Himmelblau, D.M. and Riggs, J.B., *Basic Principles and Calculations in Chemical Engineering*, 7th Edition, Prentice Hall, 2012.
2. Hougen, O.A., Watson, K.M. and Ragatz, R.A., *Chemical Process Principles, Part I: Material and Energy Balances*, 2nd Edition, CBS Publishers, 2004.
3. Bhatt, B.I. and Vora, S.M., *Stoichiometry*, 4th Edition, Tata McGraw-Hill, 2004.
4. Felder, R.M. and Rousseau, R.W., *Elementary Principles of Chemical Processes*, 3rd Edition, Wiley, 2005.
5. Narayanan, K.V. and Lakshmikutty, B., *Stoichiometry and Process Calculations*, PHI Learning, 2016.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	1		1	-	-	-	-	-	2
CO2	3	3	2	2		1	-	-	-	-	2	2
CO3	3	3	3	2		2	-	-	-	-	2	2
CO4	3	3	2	2		2	2	-	-	-	2	3

IT-104	Basics of Electrical Engineering	L-T-P: 3-0-0	3 Credits	ESC-2

Pre-requisites: None

COURSE OBJECTIVES

1. To impart knowledge of the basics electrical engineering.
2. To impart knowledge of the working of RLC circuits.
3. To impart basic knowledge about filters and magnetic circuits.
4. To impart basic knowledge about electrical machines.

COURSE OUTCOMES

After completion of the course students will be able to:

1. Understand and use Kirchhoff's Laws to solve resistive circuit problems.
2. Able to analyze resistive, inductive and capacitive circuits for transient and steady state sinusoidal solutions.
3. Understand the first order filters and magnetic circuits.
4. Understand the design of electrical machines.

COURSE CONTENT

UNIT 1: Fundamentals of DC Circuits (10 Hrs)

Passive circuit components (R, L, C) and their voltage-current characteristics; Ohm's Law, Kirchhoff's Laws, voltage and current sources; Series and parallel circuits, power and energy calculations; Mesh and Nodal analysis; Network Theorems: Superposition, Thevenin, Norton, and Maximum Power Transfer; Delta-Star and Star-Delta transformation; **Time-domain analysis** of first-order circuits (RC and RL).

UNIT 2: AC Circuit Analysis & Power Concepts (10 Hrs)

Sinusoidal waveforms, peak, average, and RMS values, phasors; Complex impedance, admittance; analysis of R, L, C, RL, RC, RLC circuits (series and parallel); Active, reactive, and apparent power; power factor and its correction; Resonance: Series and parallel; Three-phase balanced systems: Star and Delta connections, line and phase quantities, 3-φ power.

UNIT 3: Electrical Machines (10 Hrs)

D. C. Generators & Motors: Principle of operation of Generators & Motors, Speed Control of shunt motors, Flux control, Rheostatic control, voltage control, Speed control of series motors.

A. C. Generators & Motors: Principle of operation, Revolving Magnetic field, Squirrel cage and phase wound rotor, Starting of Induction motors, Direct on line and Star Delta starters, Synchronous machines.

UNIT 4: Transformers and Measuring Instruments (12 Hrs)

Transformers: Construction and principle of operation, equivalent circuit, losses in transformers, regulation and efficiency. Auto-transformer and three-phase transformer connections.

Measuring Instruments: Electromagnetism, Different Torques in Indicating instruments, Moving Iron Instruments: Construction & Principle, Attraction and Repulsion type; Moving Coil instruments: Permanent Magnet type; Dynamometer type Instruments.

TEXT AND REFERENCES BOOKS

1. Bird, J., *Electrical Circuit Theory and Technology*, 4th Edition, Elsevier, 2007.
2. Del Toro, V., *Electrical Engineering Fundamentals*, PHI (India), 1989.
3. Hambley, A.R., *Electrical Engineering*, 6th Edition, Prentice-Hall, 2011.
4. Hughes, E., *Electrical and Electronics Technology*, 10th Edition, Pearson, 2010.
5. Hughes, E., revised by Wiley, J., Brown, K. and Smith, I.M., *Hughes Electrical and Electronic Technology*, 12th Edition, Pearson, 2016.
6. Kulshrestha, D.C., *Basic Electrical Engineering*, McGraw-Hill, 2009.
7. Kothai, D.P. and Nagrath, I.J., *Basic Electrical Engineering*, McGraw-Hill, 2010.
8. Rizzoni, G., *Principles and Applications of Electrical Engineering*, 5th Edition, McGraw-Hill, 2007.
9. Waygood, A., *An Introduction to Electrical Science*, 2nd Edition, Routledge, 2019.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)

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

HVEE-114	Human Values and Ethics	L-T-P: 2-0-0	2 Credits	VAC-2

Pre-requisites: None

COURSE OBJECTIVES

To help students regulate their behavior in a professional environment as employees.

COURSE OUTCOMES

After completion of the course students will be able to:

1. Realize the importance of human values.
2. Understand that excessive desires of the mind make a person unethical and restless, while fewer desires lead to peace and professional progress.
3. Assess different types of risks involved in unethical practices. Know various means of protesting against unethical practices.
4. Assess the benefits of restraining from unethical practices like bribery, extortion, nepotism, nexus between politicians and industrialists.

COURSE CONTENT

UNIT 1 **(06 Hrs)**

Human Values: Morals, Values, Ethics, Integrity, Work ethics, Service learning, Virtues, Respect for others, Living peacefully, Caring, Sharing, Honesty, Courage, Valuing time, Cooperation, Commitment, Empathy, Self- confidence, Challenges in the workplace, Spirituality.

UNIT 2 **(08 Hrs)**

Engineering Ethics: Senses of engineering ethics, Variety of moral issues, Types of inquiries, Moral dilemma, Moral autonomy, Moral development (theories), Consensus and controversy, Profession, Models of professional roles, Responsibility, Theories about right action (Ethical theories), Self-control, Self-interest, Customs, Religion, Self-respect, Case study: Choice of the theory.

UNIT 3 **(08 Hrs)**

Safety definition, Safety and risk, Risk analysis, Assessment of safety and risk, Safe exit, Risk-benefit analysis Safety lessons from 'the challenger', Case study: Power plants, Collegiality and loyalty, Collective bargaining, Confidentiality, Conflict of interests, Occupational crime, Human rights, Employee rights, Whistle blowing, Intellectual property rights.

UNIT 4 **(06 Hrs)**

Globalization, Multinational corporations, Environmental ethics, Computer ethics, Weapons development, Engineers as managers, Consulting engineers, Engineers as expert witness, Engineers as advisors in planning and policy making, Moral leadership, Codes of ethics, Engineering council of India, Codes of ethics in Business Organizations

TEXT AND REFERENCE BOOKS

1. *A Textbook on Professional Ethics and Human Values*, by R. S. Naagarazan, New Age Publishers, 2006.
2. Professional Ethics and Human Values by D. R. Kiran, McGraw-Hill, 2014.
3. Engineering Ethics, by Charles E Harris and Micheal J Rabins, Cengage Learning Pub., 2012.
4. Introduction to Engineering Ethics by Mike W. Martin and Roland Schinzinger, McGraw-Hill, 2010.
5. Engineering Ethics by Charles B. Fleddermann, Pearson, 2014.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	-	-	-	-	-	3	-	3	1	1	-	1
CO2	-	-	-	-	-	3	-	3	1	1	-	1
CO3	-	-	-	-	-	3	-	3	1	1	-	1
CO4	-	-	-	-	-	3	-	3	1	1	-	1

CT-150	Workshop Technology	L-T-P: 0-0-2	1 Credits	SEC-2

Pre-requisites: None

COURSE OBJECTIVES

1. To impart the basics of safety precautions to be taken in lab. / workshop
2. To impart an overview of different machines used in workshop and the operations performed on these machines.
3. To impart the understanding of various welding processes.
4. To impart the understanding of sheet metals hop and fitting shop

COURSE OUTCOMES

After completion of the course students will be able to:

1. Work safely in a Lab./workshop.
2. Use machines (lathe, mill, shaper, planer, grinder, drill).
3. Do Welding.
4. Use sheet metal tools and fitting shop tools.

COURSE CONTENT

1. Safety, precautions and maintenance: Safety in shop, safety devices, safety and precautions - moving machine and equipment parts, electrical parts and connections, fire, various driving systems like chain, belt and ropes, electrical accidents, an overview of predictive, preventive and scheduled maintenance, standard guidelines to be followed in shop

2. Introduction to machine shop: Introduction to Lathe, Milling, shaper, Planer, grinder, drilling and overview of operations performed on these machines by making some jobs.

3. Introduction to welding shop: Welding, types of welding, tools and applications, gas welding and arc welding, edge preparation, various joints formation by gas welding and electric arc welding.

4. Introduction to sheet metal shop: Sheet metal tools and operations, formation of a box using sheet. Introduction to fitting shop: Introduction to fitting, tools and applications, some jobs in fitting shop.

TEXT AND REFERENCES BOOKS

1. Choudhury, S.K.H. and Roy, A.K., *Workshop Technology, Vol. 1 and Vol. 2*, Media Promoters and Publishers, 2018.
2. Raghuvanshi, B.S., *A Course in Workshop Technology, Vol. 1 and Vol. 2*, Dhanpat Rai & Co., 12th Edition, 2015.
3. Khurmi, R.S. and Gupta, J.K., *Workshop Technology (Manufacturing Processes)*, S. Chand Publications, 5th Edition, 2010.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	2	1	2	2	3	3	-	-	-	-	-	2
CO2	2	1	2	2	3	1	-	-	-	-	-	2
CO3	2	1	2	2	3	1	-	-	-	-	-	2
CO4	2	1	2	2	3	1	-	-	-	-	-	2

IT-160	Programming in Python	L-T-P: 0-0-2	1 Credits	SEC-2

Pre-requisites: None

COURSE OBJECTIVES

1. The students will learn the Programming in the Python Language
2. The students will learn usage of language implemented data structures.
3. The students shall learn the object oriented features of the Python Language.
4. The students will learn usage of the Numpy, Panda and Matplotlib

COURSE OUTCOMES

After completion of the course students will be able to:

1. write procedural programmes in Python.
2. write programs using standard data structures.
3. use object-oriented paradigm to write program in Python.
4. use Numpy, Panda and Matplotlib modules to write programs.

COURSE CONTENT

1. Identifiers, keywords, statements & expressions, variables, operators, precedence & associativity, data types, indention, comments, console I/O, type conversion. Control flow statements (if family; while & for loops; continue & break statements), exception handling. Functions, command line arguments

2. String management & usage, Lists, Dictionaries, Tuples & Sets. The operations on these data structures. Filter, Map and Reduce Function.

3. Object Oriented Programming: Properties / attributes, methods, inheritance, class variables & functions, static methods, delegation, abstract base classes, Generic function.File Handling.

4. Numpy: Dtypes, Multidimensional Arrays, Slicing, Numpy Array & Memory, Array element-wise operations, Numpy Data I/O, floating point numbers, Advanced Numpydtypes.Pandas: Using series and Data frames, Indexing & Reindexing, Deleting and merging items, Common operations, Memory usage and dtypes, Pipes, Displying data frames, Rolling & Filling operations.Matplotlib: Setting defaults, Legends, Subplots, Sharing Axes, 3D surfaces.

Note: At least two practical in each unit to be conducted. The list of practical to be notified by the concerned teacher at the start of the teaching in the semester

TEXT AND REFERENCES BOOKS

1. Gowrishankar, S. and Veena, A., *Introduction to Python Programming*, CRC Press, 2019.
2. Guttag, J.V., *Introduction to Computation and Programming Using Python*, 3rd Edition, The MIT Press, 2021.
3. Parker, J.R., *Python: An Introduction to Programming*, 2nd Edition, Mercury Learning and Information, 2021.
4. Sharma, V.K., Kumar, V., Pathak, S. and Pathak, S., *Python Programming: A Practical Approach*, CRC Press, 2021.
5. Unpingco, J., *Python Programming for Data Analysis*, Springer Nature, 2021

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	-	1	2	1	3	-	-	-	1	1	1	1
CO2	-	1	2	1	3	-	-	-	1	1	1	1
CO3	-	1	2	1	3	-	-	-	1	1	1	1
CO4	-	1	2	1	3	-	-	-	1	1	1	1

IT -152	Engineering Graphics	L-T-P: 0-0-2	1 Credits	SEC-3

Pre-requisites:None

COURSE OBJECTIVES

1. The students will learn the introduction of Engineering graphics, various equipment used, various scales, dimensions and BIS codes used while making drawings for various streams of engineering disciplines.
2. The students will learn theory of projections and projection of points.
3. The students will learn projection of lines and projection of planes.
4. The students will learn the projection of solid and development of surfaces

COURSE OUTCOMES

After completion of the course students will be able to:

1. Understand the theory of projections and projection of points.
2. do line projections.
3. do plane projections.
4. do solid projections and development of surfaces

COURSE CONTENT

1. Introduction: Engineering Graphics/Technical Drawing, Introduction to drawing equipments and use of instruments, Conventions in drawing practice. Types of lines and their uses, BIS codes for lines, technical lettering as per BIS codes, Introduction to dimensioning, Types, Concepts of scale drawing, Types of scales Theory of Projections: Theory of projections, Perspective, Orthographic, System of orthographic projection: in reference to quadrants, Projection of Points, Projection in different quadrants, Projection of point on auxiliary planes. Distance between two points, Illustration through simple problems.

2. Projection of Lines: Line Parallel to both, H.P. and V.P., Parallel to one and inclined to other, other typical cases: three view projection of straight lines, true length and angle orientation of straight line: rotation method, Trapezoidal method and auxiliary plane method, traces of line.

3. Projection of Planes: Projection of Planes Parallel to one and perpendicular to other, Perpendicular to one and inclined to other, Inclined to both reference planes, Plane oblique to reference planes, traces of planes.
4. Planes Other than the Reference Planes: Introduction of other planes (perpendicular and oblique), their traces, inclinations etc., projections of points and lines lying in the planes, conversion of oblique plane into auxiliary plane and solution of related problems.

5. Projection of Solids: Projection of solids in first or third quadrant, Axis parallel to one and perpendicular to other, Axis parallel to one inclined to other, Axis inclined to both the principal plane, Axis perpendicular to profile plane and parallel to both H.P. and V.P., Visible and invisible details in the projection, Use of rotation and auxiliary plane method.
6. Development of Surface: Purpose of development, Parallel line, radial line and triangulation method, Development of prism, cylinder, cone and pyramid surface for both right angled and oblique solids, Development of surface.

TEXT AND REFERENCES BOOKS

1. Bhatt, N.D., *Engineering Drawing*, 53rd Edition, Charotar Publishing House Pvt. Ltd., Gujarat, 2017.
2. Gill, P.S., *Engineering Drawing*, S.K. Kataria & Sons, New Delhi, 2013.
3. Giesecke, F.E., Lockhart, S., Goodman, M. and Johnson, C.M., *Technical Drawing with Engineering Graphics*, 15th Edition, Prentice Hall, USA, 2016.
4. Shah, M.B. and Rana, B.C., *Engineering Drawing*, 3rd Edition, Pearson Education, New Delhi, 2009.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	3	3	2	-	-	-	1	2	1	2
CO2	3	3	3	3	2	-	-	-	1	2	1	2
CO3	3	3	3	3	2	-	-	-	1	2	1	2
CO4	3	3	3	3	2	-	-	-	1	2	1	2

BS -162	**Engineering Physics Lab - II**	**L-T-P: 0-0-2**	**1 Credits**	**BSC-9**

INSTRUCTIONS

1.The course objectives and course outcomes are identical to that of BA119 (Engineering Physics) as this is the practical component of the corresponding theory paper.
2.The practical list shall be notified by the teacher in the first week of the class commencement under intimation to the office of the school in which the paper is being offered.

THIRD SEMESTER

Sl.	Paper ID	Course Code	Course Name	Category Code	Basic / Honours	Contact L – T - P	Credits
1		CT-201	Numerical Methods for Engineers	AEC-3	B	2 – 0 – 0	2
2		CT-203	Fluid Mechanics	PCC-3	B	3 – 0 – 0	3
3		CT-205	Mechanical Operations	PCC-4	B	4 – 0 – 0	4
4		CT-207	Heat Transfer-I	PCC-5	B	4 – 0 – 0	4
5		CT-209	Engineering Thermodynamics	PCC-6	B	4 – 0 – 0	4
6			Multidisciplinary course (To be opted among the offered electives from other discipline)	MDC-3$	B	3 – 0 – 0	3
7		CT-251	Fluid and Particle Mechanics Lab	SEC-4	B	0 – 0 – 3	2
8		CT-253	Seminar-I	VAC-3*	B	0 – 0 – 3	2
Total						**26**	**24**

CT-201	Numerical Methods for Engineers	L-T-P: 2-0-0	2 Credits	AEC-3

Pre-requisites: None

COURSE OBJECTIVES

1. To introduce basic numerical techniques for solving algebraic, differential, and integral equations.
2. To develop algorithmic thinking for engineering problem-solving.
3. To provide hands-on experience with numerical methods using programming or software tools.

COURSE OUTCOMES

1. Apply numerical techniques to solve algebraic and transcendental equations in engineering problems.
2. Use interpolation and curve-fitting techniques for data analysis and engineering estimations
3. Perform numerical integration and differentiation to solve practical engineering applications.
4. Solve ordinary differential equations using numerical methods and interpret results using computational tools.

COURSE CONTENT

UNIT 1: Solving Equations and Systems of Equations (06 Hrs)

Types of errors and error estimation in numerical computation; Roots of nonlinear equations: Bisection method, Newton-Raphson method, Secant method; Solving linear algebraic systems: Gauss elimination, Gauss-Seidel iterative method; Engineering Applications: Pipe flow (Darcy-Weisbach), static force balances, electrical resistance networks.

UNIT 2: Interpolation and Data Fitting (07Hrs)

Newton's forward and backward interpolation; Lagrange interpolation; Least squares regression: Linear fit, Polynomial fit, Exponential fit; Curve fitting and residual analysis; Engineering Applications: Sensor data interpolation, material property modelling, calibration.

UNIT 3: Numerical Differentiation and Integration (07Hrs)

Forward and backward difference methods for first and second derivatives; Trapezoidal rule, Simpson's 1/3 rule, error analysis; Adaptive quadrature; Engineering Applications: Force-displacement curves, thermal property estimation, structural load analysis.

UNIT 4: Numerical Solution of Ordinary Differential Equations (ODEs) (8Hrs)

Initial value problems; Euler's method; Modified Euler's method; Runge-Kutta methods (2nd and 4th order); Engineering Applications: Reactor kinetics, projectile motion, cooling of bodies, charging of capacitors.

TEXT AND REFERENCE BOOKS

1. Jain, M.K., Iyengar, S.R.K., and Jain, R.K., *"Numerical Methods for Scientific and Engineering Computation"*, 6th Edition, New Age International, 2012.
2. Burden, R.L. and Faires, J.D., *"Numerical Analysis"*, 10th Edition, Cengage Learning, 2016.
3. Quarteroni, A., Sacco, R., and Saleri, F., *"Numerical Mathematics"*, 2nd Edition, Springer, 2007.
4. Rao, S.S., *"Engineering Optimization: Theory and Practice"*, 4th Edition, Wiley, 2009.
5. Curtis F. Gerald and Patrick O. Wheatley, *"Applied Numerical Analysis"*, 7th Edition, Pearson, 2003.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	2	-	-	-	-	-	-	2
CO2	2	2	2	1	2	-	-	-	-	-	-	2
CO3	3	2	2	2	2	-	-	-	-	-	-	2
CO4	3	3	3	3	3	-	-	-	-	-	-	3

CT-203	Fluid Mechanics	L-T-P: 3-0-0	3 Credits	PCC-3

Pre-requisites: BS-117 & BS-114

COURSE OBJECTIVES

To provide fundamental knowledge of fluid behavior, pressure and flow measurement, internal and external flows, and fluid machinery, enabling students to analyze, design, and operate fluid-based systems in engineering practice.

COURSE OUTCOMES

After completion of the course students will be able to:

1. Understand the properties of fluids and measure pressure in static systems
2. Apply fluid kinematics and dynamics principles to solve flow problems using fundamental equations.
3. Analyze internal flows, evaluate head losses, and select suitable flow measurement devices.
4. Examine external flows, fluid-particle interactions, and understand pump and compressor operations.

COURSE CONTENT

UNIT 1: Properties of fluidandFluid Statics (10Hrs)

Fluid Classification: Newtonian & Non-Newtonian fluids, Compressible & Incompressible fluids; Fluid Properties: Density, Viscosity, Surface Tension, Vapor Pressure, Compressibility, Bulk Modulus; Fluid Rheology: Stress-strain relationships in fluids; Surface Phenomena: Surface tension, Capillarity; Fluid Statics: Pascal's law, variation of pressure in a static fluid, absolute, gauge pressure &vacuum; Pressure Measurement**:** Barometers, piezo, and types of manometers (U-tube, inverted U-tube, and inclined U-tube), pressure gauges and buoyancy.

UNIT 2: Fluid Kinematics and Dynamics (10 Hrs)

Flow Description: Streamline, Path line, Stream tube; Steady, Unsteady, Uniform, Non-uniform flows; Kinematics: Equation of Continuity, Velocity Potential and Stream Function, Irrotational Flow; Dynamics: Bernoulli's Equation and Applications, Momentum and Energy Equations, Introduction to Navier–Stokes Equation, Flow Classification: Laminar vs. Turbulent, Compressible vs. Incompressible; Boundary Layer Concepts: Development over flat plate and inside pipes, Entry length, Fully developed flow, Boundary layer separation.

UNIT 3: Internal Flows and Flow Measurement (11Hrs)

Laminar Flow in Pipes**:** Hagen–Poiseuille Equation, Velocity Profile, Pressure Drop; Turbulent Flow in Pipes**:** Friction Factor, Surface Roughness Effects, Velocity Distribution; Minor Losses**:** Expansion, Contraction, Fittings, Bends, Equivalent Length Concept; Flow in Non-Circular and Curved Pipes;Flow Measurement Devices (Closed Conduits)**:** Venturi Meter, Orifice Meter, Pitot Tube, Rotameter, Doppler-based meters, Hot Wire/Film Anemometers, Magnetic Flow Meters; Open Channel Flow**:** Weirs and Notches – basic theory.

UNIT 4: Flow Past Immersed Bodies and Fluid Machinery (11 Hrs)

External Flows: Drag, Lift, and Drag Coefficients, Flow past immersed objects; Flow through Packed Beds; Motion of Particles in Fluids: Terminal Velocity, Stokes' Law; Fluidization: Principles and applications; Pumps and Fluid Transport: Classification and Selection Criteria; Centrifugal Pumps: Construction, Working, NPSH, Priming, Cavitation, Characteristics, Specific Speed; Positive Displacement Pumps: Piston (Single & Double Acting), Plunger, Diaphragm, Rotary (Gear, Lobe, Screw), Jet and Airlift Pumps; Fans, Blowers, Compressors: Classification, Construction, and Applications.

TEXT AND REFERENCE BOOKS

1. McCabe, W.L., Smith, J.C. and Harriott, P., *Unit Operations of Chemical Engineering*, 7thEdition, McGraw-Hill International Edition, Singapore, 2005.
2. Fox, R.W. and McDonald, A.T., *Introduction to Fluid Mechanics*, 5thEdition, John Wiley & Sons, 1998.
3. Douglas, J.F., Gasiorek, J.M. and Swaffield, J.A., *Fluid Mechanics*, 4thEdition, Addison-Wesley Longman, 2001.
4. Badger, W.L. and Banchero, J.T., *Introduction to Chemical Engineering*, 1stEdition, Tata McGraw-Hill, 1997.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	-	-	2	-	-	-	-	-	-	1
CO2	3	3	2	2	-	-	-	-	-	-	-	1
CO3	3	3	2	2	2	-	-	-	-	-	-	1
CO4	3	2	2	2	2	1	1	-	-	-	1	1

CT-205	Mechanical Operations	L-T-P: 4-0-0	4 Credits	PCC-4

Pre-requisites: None

COURSE OBJECTIVES

To learn about the numerous industrial operations dealings with the particulate solids, their handling in various unit operations, and those in which particle-fluid interactions are important.

COURSE OUTCOMES

After completion of the course students will be able to:

1. Analyze particle size distribution in mixtures with varying particle sizes and shapes.
2. Evaluate size reduction principles, energy requirements, and select appropriate equipment.
3. Explain fluidization, centrifugation, and settling behavior of particles in fluids.
4. Apply principles of sedimentation, filtration, storage, mixing, and solid conveying systems.

COURSE CONTENT

UNIT 1: Characterization of particulate solids & Mechanical Separation (16 Hrs)

Particle shape, size, and distribution; Shape factor, sphericity, mixed particle size analysis and specific surface area of the mixture; Size reduction and separation of solids: Types of forces used for comminution, criteria for comminution, characteristics of comminuted products; Laws of size reduction, work index, energy utilization; Equipment's for size reduction: Jaw crusher, gyratory crusher, smooth roll crusher, toothed roll crusher, impactor, attrition mill, ball mill; critical speed of ball mill, ultrafine grinders and cutters.

Screens, ideal and actual screens, standard screens, effectiveness of screen, industrial screening equipment's, motion of screen, grizzlies, gyratory screens, vibrating screens and trommels; sub sieve analysis – air permeability, sedimentation and elutriation methods.

UNIT 2: Sedimentation and filtration (14Hrs)

Batch settling and its applications, Coe and Clevenger theory, Kynch theory, thickener design.

Classification of filtration (Batch, continuous, pressure and vacuum filtration, constant rate filtration and cake filtration); Principles of cake filtration, characteristics of filter media, filter aids and its applications; Industrial filters, sand filter, filter press, leaf filter, rotary drum filter, horizontal belt filter, bag filter, centrifugal filtration.

UNIT 3: Motion of particles through fluids (12Hrs)

Mechanics of particle motion, equation for one dimensional motion of particles through a fluid in gravitational and centrifugal field, terminal velocity, motion of spherical particles in various regimes, criterion for settling regime, hindered settling, centrifugal separators, cyclones and hydro-cyclones.

UNIT 4: Agitation, mixing and conveyors (14Hrs)

Agitation equipment, types of impellers-propellers, paddles and turbines; Flow patterns in agitated vessels, prevention of swirling, standard turbine design; Power correlation and power calculation, mixing of solids, various types of mixers and blenders; Storage of solids, open and closed storage, bulk and bin storage, slurry transport, pneumatic conveying, mechanical conveyors (belt, chain, apron, bucket, and screw).

TEXT AND REFERENCE BOOKS

1. Badger, W. L., and Banchero, J. T., *Introduction to Chemical Engineering*, 1st Edition, Tata McGraw Hill, 1997.
2. Chattopadhyay, P., *Unit Operations of Chemical Engineering*, Vol. 1, 3rd Edition, Khanna Publishers, 2006.
3. Coulson, J. M., and Richardson, J. F., *Chemical Engineering*, Vol. 1, 6th Edition, Butterworth-Heinemann, Oxford, 1999.
4. McCabe, W. L., Smith, J. C., and Harriott, P., *Unit Operations of Chemical Engineering*, 7th Edition, McGraw Hill, Singapore, 2005.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	-	3	-	-	-	-	-	1	-	2
CO2	3	3	-	3	-	-	-	-	-	1	-	2
CO3	3	3	-	3	-	-	-	-	-	1	-	2
CO4	3	3	-	3	-	-	-	-	-	1	-	2

CT-207	Heat Transfer - I	L-T-P: 4-0-0	4 Credits	PCC-5

Pre-requisites: BS-117 & BS-114

COURSE OBJECTIVES

The course aims to provide a fundamental understanding of heat transfer modes—conduction, convection, and radiation, and the basic design and analysis of heat exchangers and evaporators.

COURSE OUTCOMES

After completion of the course students will be able to:

1. Analyze heat conduction in walls, cylinders, and spheres, and assess insulation thickness.
2. Apply free and forced convection concepts and calculate heat transfer using LMTD.
3. Explain thermal radiation laws and compute radiant heat exchange between surfaces.
4. Identify types of heat exchangers and evaporators and perform basic design calculations.

COURSE CONTENT

UNIT 1: Conduction **(15 Hrs)**

Introduction to heat transfer and its importance in chemical engineering processes; modes of heat transfer: conduction, convection, radiation – basic definitions and comparisons; Fourier's law of conduction, thermal conductivity; one-dimensional steady-state heat conduction in plane wall, cylinder, and sphere; Heat conduction through composite walls and multilayer systems; Concept of thermal resistance and electrical analogy; Critical radius of insulation; Optimum thickness of insulation; Heat conduction with variable thermal conductivity and heat conduction in extended surfaces.

UNIT 2: Convection & Radiation **(20 Hrs)**

Concept of convective heat transfer, Heat transfer coefficient; free and forced convection; Boundary layer theory: Velocity and thermal boundary layers; Individual and overall heat transfer coefficients; Dimensional analysis and development of dimensionless numbers: Nusselt number(Nu), Reynolds number(Re), and Prandtl number (Pr); Log-mean temperature difference (LMTD); Empirical correlations and equation for forced convection; Equivalent diameter; Analogy between heat and momentum transfer.

Basic concepts of radiation: emission, absorption, reflection, transmissivity; Blackbody and grey body radiation; Stefan–Boltzmann law, Planck's law, Kirchhoff's law; View factors and their calculation; Radiation heat exchange between surfaces; Radiation shields and insulations

UNIT 3: Heat exchangers **(15 Hrs)**

Classification of heat exchangers; Overall heat transfer coefficient, fouling factor, and temperature profiles. LMTD and Effectiveness–NTU methods for performance analysis; Overview of industrial standards such as TEMA; Basic design aspects of shell-and-tube and double-pipe heat exchangers.

UNIT 4: Evaporators **(6 Hrs)**

Importance and industrial applications of evaporators; Single-effect, multiple-effect, short-tube, long-tube, and forced circulation evaporators; Key concepts include boiling point elevation, material and energy balances, economy and capacity calculations, and design considerations like heat transfer coefficients, fouling, and operational challenges in evaporation systems.

TEXT AND REFERENCES BOOKS

1. Holman, J. P., *Heat Transfer*, 10th Edition, McGraw-Hill Education, New York, 2020.
2. Kern, D. Q., *Process Heat Transfer*, McGraw-Hill Education, 2017.
3. McCabe, W. L., Smith, J. C., and Harriott, P., *Unit Operations of Chemical Engineering*, 7th Edition, McGraw-Hill, Singapore, 2017.
4. Coulson, J. M. and Richardson, J. F., *Chemical Engineering Vol. 1*, 6th Edition, Butterworth-Heinemann, Oxford, 1999.
5. Geankoplis, C. J., *Transport Processes and Separation Process Principles (Includes Unit Operations)*, 4th Edition, Pearson Education India, 2015.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)

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

CT-209	Engineering Thermodynamics	L-T-P: 4-0-0	4 Credits	PCC-6

Pre-requisites: BS-115 & BS-112

COURSE OBJECTIVES
To understand the engineering systems, that involves work and energy conversion, using the principles of thermodynamics concepts like internal energy, enthalpy, entropy, free energy, and laws of thermodynamics.

COURSE OUTCOMES
After completion of the course students will be able to:
1. Understand the importance of first and second law of thermodynamic
2. Solve problems involving heat energy and work interactions.
3. Understand available work from the engineering systems and their feasibility.
4. Analyze thermodynamic cycles and assess system performance.

COURSE CONTENT
UNIT 1: Basic Concepts and First Law of Thermodynamics (14Hrs)
Thermodynamic system; Surroundings; State; Property; Process; Cycle; reversible and irreversible processes; Stored energy and energy in transit; Concepts of heat and work; Simple problems with ideal gases; First law of thermodynamics for closed and open systems and its applications.

UNIT 2: Control Volume Analysis (16Hrs)
Volumetric properties: PVT behavior of pure substances, ideal gas, real gas, Cubic Equation of state; Virial Equation and Generalized Correlations for liquid and gases; Maxwell relation and its importance.
Heat Effects: Latent heat of pure substance; Standard heat of reaction, heat of formation &combustion, property changes of mixing, heat effects of mixing;
Thermodynamic properties of fluids: Fluid property relations for homogenous phases, thermodynamic diagram, Residual properties; Residual properties from Virial Equation of state, two phase systems.

UNIT 3: Entropy and Second Law of thermodynamics (16Hrs)
Limitations of the first law; Statements of the second law of thermodynamics; Heat engine; Heat pump; Refrigerator; Thermal efficiency; Coefficient of performance; Carnot cycle; Clausius inequality; Entropy; Corollaries of the second law; Second law analysis of closed and open systems; Entropy generation; Entropy and related calculations; Use of steam table and Mollier diagram.

UNIT IV: Power Cycles, Refrigeration, and Psychrometry (10Hrs)
Vapor power cycles – Carnot and Rankine; Vapor compression and absorption refrigeration cycles; Liquefaction processes; Thermodynamic gas-vapor mixtures: Psychrometry; Analysis of psychrometric processes.

TEXT AND REFERENCE BOOKS

1. Sandler, S. I., *Chemical, Biochemical, and Engineering Thermodynamics*, 5thEdition, John Wiley & Sons, Inc., New York, 2017.
2. Smith, J. M., Van Ness, H. C., and Abbott, M. M., *Introduction to Chemical Engineering Thermodynamics*, 8thEdition, The McGraw Hill Companies, Inc., USA, 2019.
3. Elliott, J. R., and Lira, C. T., *Introductory Chemical Engineering Thermodynamics*, 2ndEdition, Prentice Hall, 2012.
4. Eastop, T. D., and McConkey, A., *Applied Thermodynamics for Engineering Technologists*, 5thEdition, Addison Wesley Longman Ltd., England, 2002.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)

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

CT-251	Fluid and Particle Mechanics Lab	L-T-P: 0-0-3	2 Credits	SEC-4

Pre-requisites: None

COURSE OBJECTIVES

1. To provide hands-on training in the principles and operations of mechanical separation processes.
2. To develop skills in operating and analyzing the performance of mechanical equipment such as crushers, sieves, filters, cyclones, and ball mills.
3. To correlate theoretical knowledge with practical design and scale-up of unit operations.
4. To familiarize students with industrial safety, data acquisition, and equipment troubleshooting.

COURSE OUTCOMES

1. Perform and interpret experiments on size reduction and particle analysis.
2. Analyze mechanical separation operations such as filtration and sedimentation.
3. Assess drying and mixing behavior for solid-liquid systems.
4. Apply safety, teamwork, and reporting skills in a chemical engineering lab setup.

LIST OF EXPERIMENTS

1. Verification of **Stokes' Law** for spherical particles in a fluid.
2. Study of **sedimentation characteristics** and settling behavior of solids.
3. Evaluation of performance of a **Leaf Filter**.
4. Operation and analysis of a **Rotary Vacuum Filter**.
5. Determination of filtration rate using a **Plate & Frame Filter Press**.
6. **Screen analysis and separation efficiency** using standard sieve sets.
7. Study of **particle size reduction** using a **Jaw Crusher**.
8. Determination of grinding efficiency using a **Ball Mill**.
9. **Drying rate determination** using a **Tray Dryer**.
10. Study of drying characteristics using a **Rotary Dryer**.
11. Experiment on **Agitation and Mixing**: power consumption and mixing time

TEXT AND REFERENCE BOOKS

1. McCabe, W.L., Smith, J.C. and Harriott, P., *Unit Operations of Chemical Engineering*, 7th Edition, McGraw-Hill, 2005.
2. Richardson, J.F. and Harker, J.H., *Coulson & Richardson's Chemical Engineering, Volume 2: Particle Technology and Separation Processes*, 5th Edition, Elsevier, 2002.
3. Gupta, S.K., *Chemical Engineering Laboratory Manual*, CBS Publishers, 2nd Edition, 2015.
4. Badger, W.L. and Banchero, J.T., *Introduction to Chemical Engineering*, 1st Edition, McGraw-Hill, 1955.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	2	3	2	2	-	-	-	-	-	-	-
CO2	3	3	2	-	3	-	-	-	-	-	-	2
CO3	3	2	3	3	2	-	-	-	-	-	-	2
CO4	2	2	2	-	2	2	-	-	-	2	-	-

CT-253	Seminar - I	L-T-P: 0-0-3	2 Credits	VAC-3

Pre-requisites: None

COURSE OBJECTIVES

1. To develop students' skills in literature review, technical writing, and oral communication.
2. To expose students to recent developments, challenges, and innovations in Chemical Engineering and allied fields.
3. To encourage self-learning, critical thinking, and confidence in presenting technical topics.
4. To provide a platform to improve research aptitude and academic ethic.

COURSE OUTCOMES

1. Identify and research a recent or relevant topic in Chemical Engineering or a multidisciplinary area.
2. Review and synthesize scientific literature and technical reports effectively.
3. Deliver a structured technical seminar using effective presentation tools and techniques.
4. Demonstrate academic ethics, confidence, and critical thinking during oral presentation and discussion.

COURSE REQUIREMENTS

1. Each student shall choose a topic of interest (preferably interdisciplinary or emerging).
2. Topic must be approved by a faculty coordinator.
3. The student shall prepare a **technical report**, give an **oral presentation**, and participate in a **Q&A session**.
4. Marks will be awarded based on:
   a) Topic relevance and originality
   b) Quality of content and literature review
   c) Presentation skills
   d) Report writing and formatting
   e) Ability to answer questions

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)

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

FOURTH SEMESTER

Sl.	Paper ID	Course Code	Course Name	Category Code	Basic / Honours	Contact L – T - P	Credits
1		CT-202	Mass Transfer-I	PCC-7	B	3 – 0 – 0	3
2		CT-204	Heat Transfer-II	PCC-8	B	3 – 0 – 0	3
3		CT-206	Chemical Reaction Engineering-I	PCC-9	B	4– 0 – 0	4
4		CT-208	Chemical Engineering Thermodynamics	PCC-10	B	3 – 0 – 0	3
5		CT-210	Chemical Process Control-I	PCC-11	B	3 – 0 – 0	3
6		HS-232	Engineering Economics	AEC-4	B	2 – 0 – 0	2
		MOOCs – 3	**AI in product Management (*MOOCs/Swayam#*)**				
7		CT-252	Heat Transfer Lab	SEC-5	B	0 – 0 – 3	2
8		CT-254	Mass Transfer Lab	SEC-6	B	0 – 0 – 3	2
9		CT-256	NSS/NCC/Cultural Clubs/ Technical Society/ Technical Club*	VAC-4*	B	0 – 0 – 0	2
			Total			**24**	**24**

CT-202	Mass Transfer - I	L-T-P: 3-0-0	3 Credits	PCC-7

Pre-requisites: BS-115 & BS-112

COURSE OBJECTIVES

To learn about the basic principles of unit operations (absorption, humidification and drying) and design of equipment's involved.

COURSE OUTCOMES

After completion of the course students will be able to:

1. Concept of molecular diffusion in gas, liquid and solids, and determination of diffusion coefficient.
2. Concept of various mass transfer theories, and determination of mass transfer coefficient and mass transfer rate.
3. To understand the fundamentals and basic principles of absorption, humidification and drying with industrial applications.
4. To design of absorption, humidification and drying equipment.

COURSE CONTENT

UNIT 1: Fundamentals of Mass Transfer **(16 Hrs)**

Molecular diffusion in gases, liquids and solids; Convective mass transfer and mass transfer coefficients, mass transfer theories; Interphase mass transfer; Mass transfer accompanied by chemical reaction.

UNIT 2: Absorption **(9 Hrs)**

Equilibrium solubility of gases in liquids; Choice of solvents; Co-current and counter-current multistage operation; Concept of ideal stage, stage efficiency; Operating line; Design of packed tower, concept of height of transfer unit, determination of number of transfer unit, height equivalent theoretical plate.

UNIT 3: Humidification/Dehumidification **(10 Hrs)**

Wet bulb, dry bulb and adiabatic saturation temperatures, concept of humidity, method of changing humidity, use of psychometric charts (temperature/humidity and enthalpy/humidity charts), estimation of air quality construction and calculations for cooling tower.

UNIT 4: Drying **(7 Hrs)**

Concept of drying and its mechanism, drying equilibrium, drying rate curves, classification and application of drying equipment; Estimation of drying time and process design of dryers.

TEXT AND REFERENCE BOOKS

1. Treybal, R. E., *Mass-Transfer Operation*, 3rd Edition, McGraw-Hill, 1981.
2. Dutta, B. K., *Principles of Mass Transfer and Separation Processes*, Prentice-Hall India, 2015.
3. Geankoplis, C. J., *Transport Processes and Separation Process Principles*, 4th Edition, Pearson, 2016.
4. McCabe, W. L., Smith, J. C., and Harriott, P., *Unit Operations of Chemical Engineering*, 7th Edition, McGraw-Hill International Edition, Singapore, 2005.
5. Foust, A. S., *Principles of Unit Operations*, John Wiley & Sons, Singapore, 1994.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	2	-	3	2	-	3	-	-	3
CO2	3	3	3	2	-	3	2	-	3	-	-	3
CO3	3	3	3	2	-	3	2	-	3	-	-	3
CO4	3	3	3	2	-	1	2	-	1	-	-	3

CT-204	Heat Transfer - II	L-T-P: 3-0-0	3 Credits	PCC-8

Pre-requisites: CT-203 & CT-207

COURSE OBJECTIVES

To understand the fundamentals of multi-dimensional steady and unsteady heat conduction, and multiphase heat transfer for the design of heat transfer equipment.

COURSE OUTCOMES

After completion of the course students will be able to:

1. Solve steady and unsteady heat conduction problems using analytical and numerical methods.
2. Explain boiling and condensation mechanisms and apply design correlations.
3. Analyze heat transfer in fluidized beds using empirical relations.
4. Evaluate heat transfer performance in agitated vessels.

COURSE CONTENT

UNIT 1: Heat Conduction (09 Hrs)

Two-dimensional steady-state heat conduction in solids; Unsteady-state heat conduction: One-and unidirectional with and without internal heat generation; Analytical and numerical methods for solving heat conduction problems; Lumped heat capacity systems and applicability criteria (Biot number); Transient heat conduction in a semi-infinite solid; Heat conduction with convection boundary conditions; Finite difference methods for transient heat conduction analysis.

UNIT 2: Boiling & Condensation (16 Hrs)

Mechanisms and regimes of boiling: Natural, nucleate, transition, and film boiling; Boiling curve and critical heat flux; Simplified empirical correlations for boiling heat transfer with water and other fluids; Introduction to pool boiling and flow boiling; Design and application of reboilers in heat transfer equipment; types of reboilers: kettle, thermosyphon, and forced circulation; design considerations for reboilers and partial condensers used in distillation and separation processes.

Fundamentals and types of condensation: Film-wise and dropwise condensation; Heat transfer mechanisms involved in condensation on horizontal and vertical surfaces; Nusselt's analysis of laminar film condensation; Effects of surface properties on condensation type and efficiency; Condensation of vapors in the presence of non-condensable gases and its impact on heat transfer rates; Applications of condensers in chemical and power industries; Basic considerations in the selection of condenser type, flow arrangement, and heat transfer area.

UNIT 3: Heat transfer in Fluidized Bed (08 Hrs)

Basics of fluidization – Minimum fluidization velocity, types of fluidization; Comparison of heat transfer in fluidized and packed beds; Heat transfer to the containing wall in fluidized beds; Influence of particle size, fluid velocity, bed height, and distributor design; Effective thermal conductivity of packed and fluidized beds; Determination of heat transfer coefficients in fluidized systems; Empirical correlations: Use of Nusselt, Reynolds, and Prandtl numbers.

UNIT 4: Heat transfer in Agitated Vessels (09 Hrs)

Overview of agitated vessels and mixing equipment; Heat transfer in Jacketed vessels, helical coils, internal coils; Heat transfer mechanisms and heat transfer coefficient in agitated systems; Effect of impeller type, baffle arrangement, and fluid viscosity; Empirical correlations for agitated vessels; Estimation of heat transfer area, and power consumption.

TEXT AND REFERENCE BOOKS

1. Holman, J. P., *Heat Transfer*, 10thEdition, McGraw-Hill Education, New York, 2020.
2. Kern, D. Q., *Process Heat Transfer*, McGraw-Hill Education, 2017.
3. McCabe, W. L., Smith, J. C., and Harriott, P., *Unit Operations of Chemical Engineering*, 7thEdition, McGraw-Hill Singapore, 2017.
4. Incropera, F. P., DeWitt, D. P., Bergman, T. L., and Lavine, A. S., *Fundamentals of Heat and Mass Transfer*, John Wiley & Sons, 2018.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	-	-	-	-	-	-	-	-	-	3
CO2	3	1	-	-	-	-	-	-	-	-	-	3
CO3	3	3	3	1	-	-	-	-	-	-	-	3
CO4	3	3	3	3	-	-	-	-	-	-	-	3

CT-206	Chemical Reaction Engineering - I	L-T-P: 4-0-0	4 Credits	PCC-9

Pre-requisites: BS-115, BS-112

COURSE OBJECTIVES

To understand reaction kinetics and apply rate laws for designing ideal and non-ideal reactors, including single and multiple reaction systems with real flow behavior.

COURSE OUTCOMES

After completion of the course students will be able to:

1. To understand the fundamentals of chemical kinetics and rate laws.
2. To analyze conversion and reactor sizing problems using design equations.
3. To evaluate multiple reactions and selectivity to design reactors for optimal performance.
4. Interpret non-ideal flow using RTD and flow models.

COURSE CONTENT

UNIT 1: Reaction kinetics **(12 Hrs)**

Classification of reactions; reaction rate, rate constant and factors affecting reaction rate; Concept of rate equation; Molecularity, order of reaction, concentration-dependent rate equation and prediction of reaction rate from theory; Integral and differential method of analysis of kinetic data.

UNIT 2: Reactors & Multiple reactor system **(16 Hrs)**

Batch reactor; Types of batch reactor (constant and varying volume); Rate of conversion; Reactor designing and performance equations for (batch, mixed flow, plug flow, and recycle);

PFRs in series or parallel; Same-size CSTRs in series; Different-size CSTRs in series: Different types of reactors in series.

UNIT 3: Designing of single and parallel reactions **(16 Hrs)**

Concept of yield and selectivity; autocatalytic reactions; size comparison of single and parallel reactors; reversible reactions; potpourri of multiple reactions (reversible reactions, irreversible reactions in series and parallel, irreversible reactions of different orders), Denbigh reaction and its special cases; effect of temperature and pressure on single and multiple reactions.

UNIT 4: Flow behavior of reactors: **(12 Hrs)**

Flow patterns (contacting and non-contacting); concept of non-ideal flow; measurement and characteristics of residence time distribution (RTD studies-C, E, F and I curves); role of RTD; state of aggregation and early of mixing in determining reactor behavior; conversion in ideal and non-ideal flow reactors; models for non-ideal flow: dispersion and tank in series model.

TEXT AND REFERENCE BOOKS

1. Fogler, H. S., *Elements of Chemical Reaction Engineering*, 3rd Edition, Prentice Hall of India Ltd., 2000.
2. Levenspiel, O., *Chemical Reaction Engineering*, 3rd Edition, Wiley Eastern Ltd., New York, 1999.
3. Smith, J. M., *Chemical Engineering Kinetics*, 3rd Edition, McGraw-Hill, New York, 1981.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	3	2	-	-	2	-	-	2	-	1
CO2	3	3	3	2	-	-	1	-	-	1	-	2
CO3	3	3	3	2	-	-	2	-	-	2	-	1
CO4	3	2	-	3	-	-	1	-	-	1	-	1

CT-208	Chemical Engineering Thermodynamics	L-T-P: 3-0-0	3 Credits	PCC-10

Pre-requisites: CT-209

COURSE OBJECTIVES

To provide students with a thorough understanding of the principles and applications of thermodynamics in chemical engineering such as analyzing phase behavior, chemical reaction equilibria, and thermodynamic cycles relevant to industrial processes.

COURSE OUTCOMES

After completion of the course students will be able to:

1. Interpret mathematical expressions of various phase and reaction equilibrium phenomena.
2. Calculate vapor-liquid equilibrium for ideal and non-ideal binary systems.
3. Apply solution thermodynamics to determine phase equilibrium properties of pure substances and mixtures.
4. Evaluate equilibrium conversion and product composition of chemical reactions.

COURSE CONTENT

UNIT 1: Phase Equilibrium (12 Hrs)

PVT behavior of pure substances– qualitative discussions; Introduction to phase equilibrium; Phase rule; Concept of ideal and nonideal solutions; Qualitative vapor liquid equilibrium behavior; Simple models of vapor liquid equilibrium estimation for ideal solutions; Flash calculations; Vapor liquid equilibrium calculations for nonideal solutions at low pressure; Concept of azeotropes, vapors liquid equilibrium from azeotropic data.

UNIT 2: Solution thermodynamics theory & applications (14 Hrs)

Fundamental property relations; Chemical Potential; Phase equilibrium; Partial properties, ideal gas mixture, fugacity; Activity Coefficient: Effect of temperature and pressure, fugacity coefficient for a pure species and for species in solution and correlation for the fugacity coefficients; Excess properties; Activity Coefficient Equations: Margueles, van Laar, Wilson, NRTL, UNIQUAC; Liquid phase properties from VLE, Models for the excess Gibb's energy; Change of properties due to mixing and heat effect of mixing process.

UNIT 3: Chemical Reaction Equilibrium (08 Hrs)

Reaction coordinate; Equilibrium criteria; Standard Gibbs energy and equilibrium constant; Effect of temperature, relation of equilibrium constant to composition; Heterogeneous reaction system; Single & multiple reactions equilibria.

UNIT 4: Phase Equilibria (08 Hrs)

Equilibrium and stability; Liquid/Liquid Equilibrium, Vapor/Liquid/Liquid Equilibrium, Solid/Liquid Equilibrium, Solid/Vapor Equilibrium, Equilibrium, adsorption of gases on solids: Pure gas adsorption & Heat of adsorption; Osmotic equilibrium & Osmotic pressure.

TEXT AND REFERENCE BOOKS

1. Elliott, J. R. and Lira, C. T., *Introductory Chemical Engineering Thermodynamics*, 2nd Edition, Prentice Hall, 2012.
2. Narayanan, K. V., *A Textbook of Chemical Engineering Thermodynamics*, PHI, 2013.
3. Rao, Y. V. C., *Chemical Engineering Thermodynamics*, Universities Press, 2013.
4. Sandler, S. I., *Chemical, Biochemical, and Engineering Thermodynamics*, 5th Edition, John Wiley and Sons, Inc., New York, 2017.
5. Smith, J. M., Van Ness, H. C., and Abbott, M. M., *Introduction to Chemical Engineering Thermodynamics*, 8th Edition, The McGraw Hill Companies, Inc., USA, 2019.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	3	3	1	-	-	-	2	-	-	-
CO2	3	3	3	3	1	-	-	-	2	-	-	-
CO3	3	3	3	3	1	-	-	-	2	-	-	-
CO4	3	3	3	3	1	-	-	-	2	-	-	-

CT-210	Chemical Process Control - I	L-T-P: 3-0-0	3 Credits	PCC-11

Pre-requisites: BS-114 & BS-117

COURSE OBJECTIVES

To introduce various measuring devices (for flow, temperature, level and pressure) and principles of process control (feedback & feed forward) and analyse system dynamics, stability, and controller tuning using different methods.

COURSE OUTCOMES

After completion of the course students will be able to:

1. Understand basic concepts of measuring instruments (for temperature, pressure, flow, and level.)
2. Dynamic behaviour of various systems (First & second order) using different types of input.
3. Closed-loop response and stability using Routh array test, Root Locus method and Bode plot.
4. Tuning of controllers using different performance criteria (open loop and closed loop methods).

COURSE CONTENT

UNIT 1: Introduction to Process control (10 Hrs)

Basic process control concepts: Components of a Control system, Concept of feedback, feedforward and Inferential control. General block diagram of feedback and feed forward control systems, open loop and closed loop systems;Measuring devices for process variables(temperature, pressure level and flow) and their principles. Static characteristics of measuring devices(Accuracy, Sensitivity, Reproducibility Drift and Dead Zone), Controllers and final Control element.

UNIT 2: Dynamic Behaviour of the Physical Systems (10 Hrs)

Mathematical modelling of First-order (thermometer, liquid level, mixing etc.) and second-order systems (Interacting and non-interacting tank in series, U tube manometer), Linearization of nonlinear systems; Response of first order and second order system using different type of inputs(step, pulse, impulse, ramp and sinusoidal inputs) Distance–velocity lag.

UNIT 3: Closed Loop Systems & Stability (10 Hrs)

Development of Block diagram, overall transfer function of single loop, Loop algebra, transient response of simple control system, concept of stability, Routh array test & Root locus method.

UNIT 4: Frequency Analysis and Tuning of Controllers (12 Hrs)

Introduction to frequency response, bode plot and bode stability criterion, Tuning of Controllers by Quarter decay ratio response criterion using open loop and closed loop method and minimum Error Integral criterion (IAE, ISE, ITAE & ITSE.).

TEXT AND REFERENCE BOOKS

1. Coughanowr, D.R. and Koppel, L.B., *Process Systems Analysis and Control*, 3rd Edition, McGraw-Hill, 2009.
2. Stephanopoulos, G., *Chemical Process Control: An Introduction to Theory and Practice*, Prentice Hall of India, 1984.
3. Seborg, D.E., Edgar, T.F., and Mellichamp, D.A., *Process Dynamics and Control*, 4th Edition, John Wiley & Sons, 2017.
4. Richardson, J.F., and Peacock, D.G., *Coulson & Richardson's Chemical Engineering – Volume 3*, 3rd Edition, Elsevier, 1994.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	3	2	-	3	2	-	3	-	-	3
CO2	3	3	3	2	-	3	2	-	3	-	-	3
CO3	3	3	3	2	-	3	2	-	3	-	-	3
CO4	3	3	3	2	-	1	2	-	1	-	-	3

HS-232	Engineering Economics	L-T-P: 2-0-0	2 Credits	AEC-4

Pre-requisites: None

COURSE OBJECTIVES

This course intends to expose the students to the basic principles in economic theory and illustrate with application

COURSE OUTCOMES

1. To impart the knowledge of economic decisions, optimization and equilibrium at both individual and aggregate level.
2. To build analytical capacity to comprehend, analyze and suggest solution to an economic problem.
3. To assess the role of market mechanism in shaping the economic outcomes, individual and market behavior

COURSE CONTENT

UNIT 1: Introduction to Economics **(06 Hrs)**

Problem of scarcity and choices, Opportunity cost, Production Possibility Frontier, Economic System, Micro-Macro Paradox, Elements of Demand and Supply, Diamond water Paradox.

UNIT 2: Consumer and Producer Theory **(08 Hrs)**

Marginal Utility, Indifference Curve Analysis, Elasticity of Demand and Supply, Production Function, Law of variable Proportion, Law of Returns to scale.

UNIT 3: Market Structure **(05 Hrs)**

Perfect competition, Monopoly, Monopolistic Competition and oligopoly.

UNIT 4: Income Distribution and Factor Pricing Input Market **(05 Hrs)**

Determination of rent, wages, profit and interest, National Income accounting

TEXT AND REFERENCE BOOKS

1. Lipsey, R.G. and Chrystal, K.A., *Principles of Economics*, 12th Edition, Oxford University Press, 2011.
2. Samuelson, P.A. and Nordhaus, W.D., *Economics*, 19th Edition, Tata McGraw-Hill, New Delhi, 2010.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	2	3	3	3	2	2	3	3	3	3	2	3
CO2	2	3	3	3	3	2	3	3	3	3	2	3
CO3	2	3	3	2	2	2	3	3	3	3	3	3

CT-252	Heat Transfer Lab	L-T-P: 0-0-3	2 Credits	SEC-5

Pre-requisites: CT-205

COURSE OBJECTIVES

To give students hands-on knowledge and a better comprehension of heat transfer concepts, procedures, and equipments via practical experimentation

COURSE OUTCOMES

After completion of the course students will be able to:

1. Students will be acquainted with a variety of heat transfer devices, such as double pipe heat exchanger, shell and tube, plate heat exchangers, and other pertinent equipment.
2. Students will develop the ability to conduct experiments on heat transfer equipment, and gather data
3. Students will be able to evaluate LMTD, overall heat transfer coefficients, efficiency of equipment and draw reasonable inferences from experimental data.
4. It will enable students to prepare for industries where understanding heat transfer process is essential, like process design, equipment selection, and optimization.

LIST OF EXPERIMENTS

Determination of heat transfer co-efficient in following equipment

1. Shell & tube heat exchanger
2. Double pipe heat exchanger
3. Plate type heat exchanger
4. Finned tube heat exchanger
5. Vertical condenser
6. Agitated vessel
7. Film wise and drop wise condensation unit

TEXT AND REFERENCE BOOKS

1. Holman, J. P., *Heat Transfer*, 10th Edition, McGraw-Hill Education, New York, 2020.
2. Kern, D. Q.,*Process Heat Transfer*, McGraw-Hill Education, 2017.
3. McCabe, W. L., Smith, J. C., and Harriott, P., *Unit Operations of Chemical Engineering*, 7th Edition, McGraw-Hill, Singapore, 2017.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	2	3	-	1	-	-	-	-	-	-	2
CO2	3	3	2	3	2	-	-	-	-	2	-	2
CO3	3	3	3	3	2	-	-	-	-	-	-	3
CO4	2	2	3	2	3	2	-	-	1	2	2	3

CT-254	Mass Transfer Lab	L-T-P: 0-0-3	2 Credits	SEC-6

Pre-requisites: None

COURSE OBJECTIVES

1. To provide practical exposure to mass transfer operations such as absorption, distillation, drying, and extraction.
2. To help students analyze experimental data and interpret mass transfer coefficients and process efficiency.
3. To correlate theoretical principles with real-world separation equipment.

COURSE OUTCOMES

After completion of the course students will be able to:

1. Demonstrate the working of mass transfer equipment such as dryers, absorbers, extractors, etc.
2. Determine mass transfer coefficients and efficiencies from experimental data.
3. Analyze the performance of equipment for different separation processes.
4. Develop hands-on skills in using laboratory-scale mass transfer systems.

LIST OF EXPERIMENTS

1. **Simple Distillation** – Determination of vapor-liquid equilibrium and separation efficiency
2. **Packed Column Absorber** – Determination of mass transfer coefficient
3. **Cooling Tower Unit** – Measurement of humidity and tower efficiency
4. **Liquid-Liquid Extraction** – Study of solute transfer and stage-wise separation
5. **Solid-Liquid Leaching** – Extraction of solute from solid using a solvent
6. **Drying** – Determination of drying rate and moisture content using tray dryer
7. **Rotary Dryer** – Study of continuous drying operation
8. **Crystallization** – Determination of yield from a batch crystallizer
9. **Diffusion in Liquids** – Determination of diffusivity
10. **Humidification-Dehumidification Column** – Study of air-water mass transfer

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	2	2	3	-	1	-	-	-	1	2	-	2
CO2	3	3	3	2	2	-	-	-	-	2	2	2
CO3	3	2	3	3	2	-	-	-	2	2	1	2
CO4	2	3	3	2	3	-	-	-	2	2	-	3

CT-256	NSS/NCC/Cultural Clubs/ Technical Society/ Technical Club	L-T-P: 0-0-0	2 Credits	VAC-4

FIFTH SEMESTER

Sl.	Paper ID	Course Code	Course Name	Category Code	Basic / Honours	Contact L – T - P	Credits
1		CT-301	Mass Transfer-II	PCC-12	B	3 – 0 – 0	3
2		CT-303	Chemical Process Industries	PCC-13	B	3 – 0 – 0	3
3		**CT-305**	**Chemical Process Control-II**	**PCC-14**	**H**	**3 – 0 – 0**	**3**
4		**CT-307**	**Chemical Reaction Engineering-II**	**PCC-15**	**H**	**3 – 0 – 0**	**3**
5		CT-309	Computational Methods for Chemical Engineers	PCC-16	B	4 – 0 – 0	4
6			**Elective - I**	**PEC-1**	**B**	**3 – 0 – 0**	**3**
		MOOCs – 4	**Equivalent course from *MOOCs/Swayam#***				
7		CT-351	Chemical Reaction Engineering Lab	SEC-7	B	0 – 0 – 3	2
8		CT-353	Chemical Process Control Lab	SEC-8	B	0 – 0 – 3	2
9		CT-355	Computational Methods for Chemical Engineers Lab	SEC-9	B	0 – 0 – 3	2
10		CT-357	Summer Training / Summer Project	AEC-5	B	0 – 0 – 0	2
			Total			**28**	**27**

Elective-I List:

Sl.	Paper ID	Course Code	Course Name
1		CT-311	Fundamentals of Polymer Engineering
2		CT-313	Air Pollution Control Engineering
3		CT-315	Alternative Energy Sources
4		CT-317	Upstream Processing for Bioprocesses

CT-301	Mass Transfer - II	L-T-P: 3-0-0	3 Credits	PCC-12

Pre-requisites: CT-202

COURSE OBJECTIVES

To learn about the basic principles of unit operations (distillation, extraction, adsorption and membrane separations) and design of equipment involved.

COURSE OUTCOMES

After completion of the course students will be able to:

1. To analyze vapor-liquid, liquid-liquid and solid-liquid equilibrium data.
2. To understand the fundamentals and basic principles of distillation, liquid-liquid extraction, solid-liquid extraction, and adsorption with industrial applications.
3. To determination the number of stages and separation efficiency in distillation, extraction and adsorption for co-current, counter-current and cross-current operations.
4. To design the distillation, extraction and adsorption equipment.

COURSE CONTENT

UNIT 1: Distillation **(14 Hrs)**

Fundamentals of vapor-liquid equilibrium, relative volatility, ideal solutions, positive and negative deviations from ideality; Enthalpy-concentration diagrams; Flash distillation and batch distillation for binary and multicomponent systems; Steam distillation, azeotropic distillation; Continuous multistage fractionation of binary and multicomponent systems, calculation of number of stages, feed tray, optimum reflux ratio using Ponchon-Savarit method and McCabe-Thiele method; Partial vaporization/condensation, Fenske-underwood-Gilliland method for multicomponent distillation; Distillation in packed tower.

UNIT 2: Liquid-Liquid extraction **(10 Hrs)**

Liquid-liquid equilibrium, choice of solvent; Design calculations of single/ multistage co-current/counter current extraction; Equipment for liquid-liquid extraction; Designing of extraction equipment's.

Leaching: Theory and operation, solid-liquid extraction equilibria, designing of leaching equipment's.

UNIT 3: Adsorption **(10 Hrs)**

Nature, characteristics and applications of adsorbents; Batch adsorption; Adsorption equilibria and adsorption kinetics; Multi-component adsorption; Isotherms: Langmuir, Freundlich, and BET design of fixed bed adsorbers; Concepts of chromatography and ion exchange.

UNIT 4: Membrane separation & Crystallization **(08 Hrs)**

Basic principles and applications of micro-filtration, ultra-filtration, nano-filtration and reverse osmosis.

Super-saturation, nucleation, principle of crystallization, crystallization rate, equilibria and yields, nucleation, crystal growth, caking of crystals, application of crystallization, crystallization equipment.

TEXT AND REFERENCE BOOKS

1. Treybal, R.E., *Mass-Transfer Operations*, 3rd Edition, McGraw Hill, 1981.
2. Dutta, B.K., *Principles of Mass Transfer and Separation Processes*, 1st Edition, Prentice-Hall India, 2015.
3. Geankoplis, C.J., *Transport Processes and Separation Process Principles*, 4th Edition, Pearson, 2016.
4. McCabe, W.L., Smith, J.C., and Harriott, P., *Unit Operations of Chemical Engineering*, 7th Edition, McGraw Hill International Edition, Singapore, 2005.
5. Foust, A.S., *Principles of Unit Operations*, 2nd Edition, John Wiley & Sons, Singapore, 1994.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	-	3	2	-	-	-	-	3
CO2	3	3	3	3	-	3	2	-	-	-	-	3
CO3	3	3	3	3	-	3	2	-	-	-	-	3
CO4	3	3	3	3	-	3	2	-	-	-	-	3

CT-303	Chemical Process Industries	L-T-P: 3-0-0	3 Credits	PCC-13

Pre-requisites: None

COURSE OBJECTIVE

To provide an overview of key chemical and allied industries, their raw materials, manufacturing processes, flow diagrams, and integration of energy, utility, and environmental aspects.

COURSE OUTCOMES

After completion of the course students will be able to:

1. Identify major chemical process industries and understand their basic flow diagrams.
2. Describe the manufacturing processes of industrial acids, fertilizers, cement, and chlor-alkali products.
3. Explain hydrogen production methods, fermentation processes, and sugar, starch, and pulp industries.
4. Understand fuel types, refining processes, and handling of solid, liquid, and gaseous fuels.

COURSE CONTENT

UNIT 1 **(9 Hrs)**

Overview of Indian and global chemical industries; Classification and flow diagrams; Engineering problems, equipment safety, waste disposal, quality control, and environmental aspects. Manufacture of industrial acids like sulfuric, hydrochloric, and nitric acid.

UNIT 2 **(16Hrs)**

Chlor-alkali industries: Soda ash, solvay process, dual process, electrolytic process, and caustic soda (raw materials, manufacturing process, flow-sheet, sequence of operation, and major engineering problems).
Cement industries: Cement classification and manufacturing by wet and dry methods.
Fertilizer Industries: Manufacturing of fertilizers (Ammonia based fertilizers, phosphatic, phosphoric acid, potash fertilizers, and N-P-K values); Corrosion problems and material of construction.

UNIT 3 **(8 Hrs)**

Sugar & Starch Industries: Extraction of sugarcane to produce crystalline white sugar; Starch production from maize, production of dextrin by starch hydrolysis.
Pulp and Paper Industries: Types of paper products, paper manufacturing processes (raw materials, manufacturing process, flow-sheet, sequence of operation, and major engineering problems); Chemical recovery from sulfate pulp digestion liquor.

UNIT 4 **(9 Hrs)**

Petroleum and Refining Industries: Physical and chemical characteristics of solid, liquid and gaseous fuel and applications,**Introduction to** fuel conversion technologies; Refining and separation, Handling, storage, and commercialization of solid, liquid and gaseous fuel.

TEXT AND REFERENCE BOOKS

1. Dryden, C. E., and Rao, M. G., *Outlines of Chemical Technology*. Affiliated East-West Press, 2009.
2. Austin, G. T. *Shreve's, Chemical Process Industries*. 5th Edition, McGraw Hill, 2016.
3. Ghoshal, S. K., Sanyal, S. K., and Datta, S. *Introduction to Chemical Engineering*. Tata McGraw Hill, New Delhi, 2006.
4. Kirk, R., and Othmer, D. *Encyclopedia of Chemical Technology*. 5th Edition, Wiley, 2004.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	-	-	3	-	-	-	-	1
CO2	3	3	3	3	-	-	3	-	-	-	-	1
CO3	3	3	3	3	-	-	3	-	-	-	-	1
CO4	3	3	3	3	-	-	3	-	-	-	-	2

CT-305	Chemical Process Control - II	L-T-P: 3-0-0	3 Credits	PCC-14

Pre-requisites: CT-210

COURSE OBJECTIVES

To Understand the fundamentals of advanced control systems (Multiloop, Feed-forward, adaptive and inferential Control system.) and to know the issues with multivariable process control systems and their solution as well as introduction to digital process control and batch process control.

COURSE OUTCOMES

After completion of the course students will be able to:

1. Concept of Multiple loop control systems.
2. Challenges with Multivariable process control and their solution
3. To understand the fundamentals of digital process control
4. Concept of Batch process Control

COURSE CONTENT

UNIT 1: Multiple Loop and Feed Forward Control Systems (12 Hrs)

Multiple loop control systems: (Cascade, selective: override & Auctioneering control and Split range control systems); Design of Feedforward control system; Generalized block diagram of feed-forward -feedback control system and Ratio Control system.

UNIT 2: Multivariable Process Control (10 Hrs)

Loop interactions: Positive and Negative Interaction, quantification of interaction, pairing rule of control and manipulated variables, Relative gain of n*n systems, minimization of interaction between interacting loops: Decoupler design for 2*2 systems.

UNIT 3: Process Control Using Digital Computers (10 Hrs)

Digital Computer control loops, From continuous to discrete -time systems, z-transforms and Discrete -time response of dynamic systems; Design of digital feedback Controllers.

UNIT 4: Complex Control System and Batch Process Control (10 Hrs)

Complex process Control system: Adaptive: Programmed or scheduled and self-adaptive control and Inferential Control system; Batch Control systems, sequential and logic control, Control during the Batch and Run-to- Run Control.

TEXT AND REFERENCE BOOKS

1. Coughanowr, D.R. and Koppel, L.B., *Process Systems Analysis and Control*, 3rd Edition, McGraw Hill, 2009.
2. Stephanopoulos, G., *Chemical Process Control: An Introduction to Theory and Practice*, Prentice Hall of India, 1984.
3. Smith, C.A. and Corripio, A.B., *Principles and Practice of Automatic Process Control*, 3rd Edition, John Wiley & Sons, 2006.
4. Seborg, D.E., Edgar, T.F., and Mellichamp, D.A., *Process Dynamics and Control*, 4th Edition, John Wiley & Sons, 2017.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	2	-	3	2	-	3	-	-	3
CO2	3	3	3	2	-	3	2	-	3	-	-	3
CO3	3	3	3	2	-	3	2	-	3	-	-	3
CO4	3	3	3	2	-	1	2	-	1	-	-	3

CT-307	Chemical Reaction Engineering - II	L-T-P: 3-0-0	3 Credits	PCC-15

Pre-requisites: CT-206 & CT-207

COURSE OBJECTIVES

The course is designed to provide an understanding of catalysts, their physical characteristics, mechanisms of action, and the kinetics of both catalytic and non-catalytic heterogeneous chemical reactions.

COURSE OUTCOMES

After completion of the course student will be able to:

1. Understand basic concepts of heterogeneous catalysis.
2. Derive rate laws for heterogeneous catalytic reactions.
3. Design and analyze reactors, their performance equation and heat effects during reactions.
4. Evaluate the fluid –particle non catalytic systems for impact of particle size, velocity, and fluid properties on mass transfer-controlled reactions.

COURSE CONTENT

UNIT 1: Introduction to Catalysis **(10 Hrs)**

Catalysis History; Classification of catalysts; Precipitation and sol gel synthesis; Physical and Chemisorption; Adsorption isotherms; Determination of surface area and pore volume of the catalyst.

UNIT 2: Heterogeneous Catalysis **(12 Hrs)**

Rate equation for surface kinetics; Steps involved in catalytic reactions; Porous catalysts; Pore diffusion resistance; Effectiveness factor; Heat Effects during reaction; Performance equation; Experimental methods for finding rates; Product distribution in multiple reactions.

UNIT 3: Catalytic Reactors **(10 Hrs)**

Packed bed reactor;Isothermal &adiabatic operations; 1-D and 2D model; Suspended solid systems; Fluidized bed reactor; Heat Transfer and mixing in FBR; Bubbling fluidized bed; K-L model; Circulating fluidized bed.

UNIT 4: Fluid particle non-catalytic reactions (Kinetics and Design) **(10 Hrs)**

Model selection; Shrinking core model for spherical particles of unchangeable size; Controlling resistance; Determination of rate controlling step; Conversion estimation for single/mixed particle, with changing or unchanging size in uniform gas composition.

TEXT AND REFERENCE BOOKS

1. Fogler, H. S., *Elements of Chemical Reaction Engineering*, 3rd Edition, Prentice Hall of India Ltd., 2000.
2. Levenspiel, O., *Chemical Reaction Engineering*, 3rd Edition, Wiley Eastern Ltd., New York, 1999.
3. Smith, J. M., *Chemical Engineering Kinetics*, 3rd Edition, McGraw-Hill, New York, 1981.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	3	2	-	3	2	-	-	-	-	2
CO2	3	3	3	2	-	3	2	-	-	-	-	2
CO3	3	3	3	2	-	3	2	-	-	-	-	2
CO4	3	3	3	1	-	3	2	-	-	-	-	2

CT-309	Computational Methods for Chemical Engineers	L-T-P: 4-0-0	4 Credits	PCC-16

Pre-requisites: CT-211

COURSE OBJECTIVES

To describe various chemical engineering problems into mathematical form by applying appropriate microscopic and macroscopic balances, and to solve the developed model equations by suitable numerical and analytical techniques.

COURSE OUTCOMES

1. To formulate the physical problems encountered in chemical engineering into mathematical equations.
2. To identify the appropriate numerical solution technique for a given model equation.
3. To apply the appropriate numerical solution technique to solve the model equation.
4. To analyze the results of the different solution techniques.

COURSE CONTENT

UNIT 1 **(12 Hrs)**

Formulation of mathematical models from chemical engineering aspects: Application of law of conservation (mass, momentum and energy), Classification of mathematical models, Models resulting from different equations (algebraic equations, ordinary differential equations and partial differential equations).

Numerical solution of linear and non-linear algebraic equation**.**

UNIT 2 **(16 Hrs)**

Numerical solution of initial value problems in ordinary differential equations encountered in heat transfer, chemical reaction engineering problems including the calculation of temperature profile in heat exchanger, stirred tank reactor etc., and the calculation of concentration profile in batch reactor, stirred reactor and plug flow reactor etc.

UNIT 3 **(14 Hrs)**

Numerical solution of boundary value problems in ordinary differential equations encountered in heat transfer and chemical reaction engineering problems; Numerical solution of convection-diffusion and reaction-diffusion problems encountered in chemical engineering.

UNIT 4 **(14 Hrs)**

Classification of partial differential equations; Explicit and Implicit discretization; Crank Nicolson discretization; Numerical solution of one-dimensional transient heat conduction in rectangular slab and cylinder, transient diffusion in sphere; Numerical solution of two-dimensional steady and transient heat conduction; Application of Laplace Transform in solving chemical engineering problems.

TEXT AND REFERENCE BOOKS

1. Ray, A.K. and Gupta, S.K., *Mathematical Methods in Chemical & Environmental Engineering*, Thomson Learning, 2004.
2. Ahuja, P., *Introduction to Numerical Methods in Chemical Engineering*, PHI Learning, 2010.
3. Gupta, S.K., *Numerical Methods for Engineers*, New Age International Publishers, 2ndEdition, 2010.
4. Jenson, V.G. and Jeffreys, G.V., *Mathematical Methods in Chemical Engineering*, Academic Press, 2ndEdition, 2012.
5. Mickley, H.S., Sherwood, T.K., and Reed, C.E., *Applied Mathematics in Chemical Engineering*, McGraw-Hill, New York, 1957 (Reprint 2001).

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	3	2	1	1	2	1	1	1	1	1
CO2	3	3	3	2	1	1	2	1	1	1	1	1
CO3	3	3	3	2	1	1	2	1	1	1	1	1
CO4	3	3	3	2	1	1	2	1	1	1	1	1

CT-351	Chemical Reaction Engineering Lab	L-T-P: 0-0-3	2 Credits	SEC-7

Pre-requisites: CT-206

COURSE OBJECTIVE

1. To provide hands-on experience with chemical reactor systems.
2. To develop analytical skills to evaluate reactor performance.
3. To correlate theoretical kinetic concepts with real-life chemical reaction engineering.

COURSE OUTCOMES

After completion of the course students will be able to:

1. Understand the working of various chemical reactors including CSTR, PFR, and batch reactors.
2. Analyze kinetic data and estimate rate constants, reaction order, and conversion.
3. Interpret residence time distribution and assess reactor performance.
4. Demonstrate safety and data handling practices in reaction engineering experiments.

COURSE CONTENT

1. Study of **Isothermal Batch Reactor** – Determination of reaction kinetics
2. Study of **Isothermal CSTR** – Performance evaluation and comparison with theoretical models
3. Study of **Plug Flow Reactor (PFR)** – Determination of conversion and residence time
4. **RTD Studies** in packed bed or CSTR systems
5. Study of **Semi-batch reactor** for first-order and second-order reactions
6. **Series/Parallel Reactor System** performance evaluation
7. **Catalytic Reactor** studies – Estimation of effectiveness factor and reaction rate
8. **Adiabatic Reactor** – Temperature profile and conversion
9. Study of **Enzymatic reactions** in batch mode (if setup available)
10. **Reactor safety and troubleshooting** simulation/analysis

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	-	1	-	-	-	-	2	-	2
CO2	3	3	3	2	2	-	-	-	-	2	1	2
CO3	3	3	3	3	2	-	-	-	2	2	-	3
CO4	2	3	3	2	1	2	2	1	2	2	-	2

CT-353	Chemical Process Control Lab	L-T-P: 0-0-3	2 Credits	SEC-8

Pre-requisites: CT-208

COURSE OBJECTIVE

1. To introduce students to process control elements through hands-on experiments.
2. To develop analytical skills for interpreting system dynamics and controller behavior.
3. To enable understanding of tuning and implementation of PID controllers in real-time systems.

COURSE OUTCOMES

After completion of the course students will be able to:

1. Identify basic elements of control systems and explain system dynamics.
2. Perform experiments to determine process reaction curves and time constants.
3. Tune controllers and study the effect of control parameters (P, PI, PID).
4. Analyze closed-loop system behavior for various chemical process setups.

COURSE CONTENT

1. Study of **first-order and second-order system dynamics**
2. **Interacting and non-interacting tank systems**
3. **Step and impulse response** for process systems
4. Open-loop and closed-loop control for **level control system**
5. Open-loop and closed-loop control for **flow control system**
6. Tuning of **PID controller** (Ziegler-Nichols method or others)
7. Control of **pressure control system**
8. Control of **temperature process** using feedback control
9. Analysis of **control valve characteristics**
10. **Simulation-based process control** using MATLAB/Simulink/LabVIEW (if available)

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	-	2	-	-	-	-	2	-	-
CO2	3	3	2	2	3	-	-	-	-	2	-	-
CO3	3	3	3	3	3	-	-	-	2	2	-	2
CO4	3	2	3	3	2	-	-	-	2	2	-	2

CT-355	Computational Methods for Chemical Engineers Lab	L-T-P: 0-0-3	2 Credits	SEC-9

Pre-requisites: CT-211

COURSE OBJECTIVE

1. To familiarize students with numerical and computational tools used in chemical engineering.
2. To apply algorithms for solving mathematical models of chemical processes.
3. To provide hands-on experience in software such as MATLAB, Python, or Excel for chemical engineering applications.

COURSE OUTCOMES

After completion of the course students will be able to:

1. Understand the role of numerical methods in solving chemical engineering problems.
2. Apply computational techniques to solve linear/nonlinear equations, ODEs, and PDEs.
3. Use MATLAB/Python/Excel for implementing numerical methods.
4. Analyze real-time process data using curve fitting and optimization tools.

COURSE CONTENT

1. Solution of linear algebraic equations using **Gauss elimination** and **Gauss-Seidel** methods.
2. **Root-finding** techniques (Bisection, Newton-Raphson) for chemical equations.
3. Numerical integration using **Trapezoidal** and **Simpson's rule** for reactor models.
4. **Ordinary Differential Equations (ODEs)**: Application to CSTR and batch reactor problems.
5. Partial Differential Equations (PDEs): Heat conduction using **finite difference method**.
6. **Curve fitting** and regression analysis for experimental data.
7. **Optimization techniques** using MATLAB/Excel Solver for cost/reaction optimization.
8. Application of **interpolation techniques** to process data (Lagrange, Newton).
9. Solving **mass and energy balances** on multi-unit processes.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	2	2	2	3	-	-	-	-	2	-	-
CO2	3	3	3	3	3	-	-	-	-	2	-	2
CO3	2	3	2	2	3	-	-	-	-	2	-	-
CO4	2	2	3	3	3	-	-	-	2	3	-	2

CT-357	Summer Training / Summer Projects	L-T-P: 0-0-0	2 Credits	AEC-5

Pre-requisites: None

COURSE OBJECTIVE

1. To provide industry exposure and real-world problem-solving experiences to students.
2. To bridge the gap between academic knowledge and industrial applications.
3. To develop soft skills, safety practices, and teamwork abilities in professional settings.
4. To expose students to modern tools, equipment, and processes used in industry/R&D/academia.

COURSE OUTCOMES

After completion of the course students will be able to:

1. Understand the structure, operation, and environment of a chemical process industry or research organization.
2. Apply theoretical knowledge to practical problems in chemical or energy systems.
3. Demonstrate safety practices, process understanding, and professional communication skills.
4. Prepare and present technical reports and presentations summarizing training experiences and learnings.

SUGGESTED AREAS FOR TRAINING

- Chemical or Petrochemical Plants
- Energy and Power Generation Industries
- Environmental or Wastewater Treatment Units
- Cement, Fertilizer, Polymer, or Food Processing Plants
- Research Labs (CSIR, DRDO, BARC, IITs, etc.)
- Startups, MSMEs, or Consultancy Firms
- Academic Projects in Interdisciplinary Areas (AI/ML in process control, sustainability etc.)

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	2	2	3	2	2	3	3	2	2	2	1	3
CO2	3	3	3	2	3	2	2	1	2	2	1	3
CO3	2	1	2	2	3	3	3	2	3	2	2	2
CO4	2	1	2	2	2	-	-	-	2	3	2	2

CT-311	Fundamentals of Polymer Engineering	L-T-P: 3-0-0	3 Credits	PEC-1(1)

Pre-requisites:None

COURSE OBJECTIVES

To elaborate engineering aspects of polymers that are necessary to use polymers for our daily life as well as in engineering fields.

COURSE OUTCOMES

1. The student will be familiar with fundamental knowledge of structure-properties relationship of polymers and their link with applications.
2. The student will demonstrate an understanding of approaches to engineering views of polymer synthesis and kinetics.
3. The student will gain experiences in applying unique properties of polymers to solve problems and challenges in our life.
4. The student will demonstrate the ability to develop case studies of polymers with a focus on fundamentals, fabrication, characterization, and applications.

COURSE CONTENT

UNIT 1: Architecture and Properties of Polymers **(10 Hrs)**

The petrochemical industry-building blocks of polymers; Structure-properties and classifications of polymers; Molecular weight and its distribution; Aspects of Molecular weight measurements; Thermo-physical properties of polymers.

UNIT 2: Polymer Reaction Engineering **(12 Hrs)**

The mechanism of polymer formation; Kinetic analysis of step-growth, chain-growth and copolymerization; Reaction engineering of Bulk, Solution, Suspension and Emulsion polymerization processes; Polymerization reactors- Batch, Tubular and CSTR.

UNIT 3: Polymer Physics **(10 Hrs)**

Thermodynamics of polymer solutions and mixtures; Mechanical Polymer viscoelasticity-Flow behavior of polymeric fluids and polymer rheology, Mechanical models of linear viscoelastics response; Deformation of solid polymers.

UNIT 4: Technology of Polymers **(10 Hrs)**

Polymer products and product design; Polymer compounding - Additives and reinforcement; Unit operations in polymer processing-Extrusion process, Blow molding, Injection moulding, and the concepts of other molding processes;, Properties of commodity polymers and their applications-Polyethylene, PP, PS and PVC; Properties of engineering polymers and their applications-Nylon, PF resin, Fluoropolymers, NR and Silicone polymers.

TEXT AND REFERENCE BOOKS

1. Odian, G.,*Principles of Polymerization*, 4th Edition, John Wiley & Sons, 2004.
2. Ebewele, R.O., *Polymer Science and Technology*, 1st Edition, CRC Press, 2000.
3. Kumar, A. and Gupta, R.K.,*Fundamentals of Polymers*, 2nd Edition, McGraw-Hill, 2003.
4. Crawford, R.J., and Martin, P.J., *Plastics Engineering*, 4th Edition, Butterworth-Heinemann, 2019.
5. Fried, J.R., *Polymer Science and Technology*, 3rd Edition, Prentice Hall of India, 2014.
6. Mark, H.F., *Encyclopaedia of Polymer Science and Technology*, 3rd Edition, Wiley-Interscience, 2014.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	2	-	1	-	-	2	3	-	-	1	-	3
CO2	3	3	3	2	-	3	3	-	-	1	-	3
CO3	3	2	3	2	2	2	2	-	-	2	2	3
CO4	2	2	3	-	2	3	2	1	2	2	2	3

CT-313	Air Pollution Control Engineering	L-T-P: 3-0-0	3 Credits	PEC-1(2)

Pre-requisites: None

COURSE OBJECTIVES

To introduce students to the sources of air pollution, air quality parameters, and essential control methods for sustainable air quality management.

COURSE OUTCOMES

After completing the course, students will be able to:

1. Analyze air quality based on standard parameters.
2. Identify sources of air pollution and their effects.
3. Explain primary, secondary, and advanced air pollution control techniques.
4. Select appropriate methods for different pollution scenarios.

COURSE CONTENT

UNIT 1: Air pollution overview (10 Hrs)

Air pollution; Sources of air pollution: natural vs. anthropogenic, point vs. non-point; Air pollutants (PM, SO_2, NO_x, CO, O_3, VOCs); PM sources (industry, construction, vehicles, dust), gaseous sources (combustion, industrial, vehicles), indoor sources (cooking, heating, smoking); effects on health, environment, economy; air quality and emission standards (WHO, IS, NAAQS); regulatory framework (Air Act 1981).

UNIT 2: Air sampling, meteorology & management (10 Hrs)

Air sampling: Types, sampling train, methods for PM and gases, stack monitoring, analysis; Meteorology: Urban micrometeorology, boundary layer, inversion, stability, plume behavior, wind profiles, pollution roses; Air quality management: Emission inventory, data analysis, indices, global practices.

UNIT 3: Pollution control techniques (12 Hrs)

Electrostatic Precipitator (ESP); Baghouse Filter (Fabric Filter); Cyclone Separator; Wet Scrubber; Venturi Scrubber; Catalytic Converter; Selective Catalytic Reduction (SCR); Selective Non-Catalytic Reduction (SNCR); Activated Carbon Adsorption; Thermal Oxidizer (Incinerator); Flue Gas Desulfurization (FGD); Low NOx Burners; Spray Tower Scrubber; Carbon Injection System; Biofilter

UNIT 4: Indoor air pollution control and current issues (10 Hrs)

Indoor pollutants (VOCs, bioaerosols, CO, PM, smoke); Ventilation; Air purifiers, UV, humidity control etc. Current issues: HAPs, CO_2 budgeting, climate change impacts, global mitigation/adaptation strategies.

TEXT AND REFERENCE BOOKS

1. Wark, K. and Warner, C.F., *Air Pollution: Its Origin and Control*, 3rd Edition, Pearson Education, 2000.
2. de Nevers, N., *Air Pollution Control Engineering*, 2nd Edition, Waveland Press, 2010.
3. Rao, M.N. and Rao, H.V.N., *Air and Water Pollution Control Engineering*, 2nd Edition, McGraw-Hill Education, 2007.
4. Vallero, D.A., *Fundamentals of Air Pollution*, 5th Edition, Academic Press (Elsevier), 2014.
5. Colls, J., *Air Pollution: Measurement, Modelling and Mitigation*, 3rd Edition, CRC Press, 2002

Course Outcome (CO) to Programme Outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	2	2	1	1	-	-	-	-	1	-	-	3
CO2	3	3	1	1	-	-	-	-	1	-	-	3
CO3	3	3	1	1	-	3	-	-	-	-	-	3
CO4	3	2	3	3	-	3	-	-	-	-	-	3

CT-315	Alternative Energy Sources	L-T-P: 3-0-0	3 Credits	PEC-1(3)

Pre-requisites: None

COURSE OBJECTIVES

To introduce students to various alternative and renewable energy sources, their working principles, applications, and role in sustainable energy development.

COURSE OUTCOMES

After completion of the course students will be able to:

1. Explain the importance and classification of alternative energy sources.
2. Analyze the principles and applications of solar, wind, biomass, geothermal, and ocean energy.
3. Evaluate energy generation potential and limitations of various non-conventional energy systems.
4. Propose feasible alternative energy solutions for real-world applications.

COURSE CONTENT

UNIT 1 **(10 Hrs)**

Principles of renewable energy; Energy and sustainable development; Fundamentals and social implications. worldwide renewable energy availability, renewable energy availability in India.

Global and Indian energy scenario; Limitations of conventional energy sources; Need and scope of alternative energy; Energy economics and environmental implications; Overview of renewable vs. non-renewable energy.

UNIT 2 **(10 Hrs)**

Solar Energy: Solar radiation, measurement, and estimation; Solar thermal systems: collectors, water heaters, dryers, concentrators; Photovoltaic systems: working, efficiency, and applications; Solar passive architecture and solar power plants.

UNIT 3 **(16 Hrs)**

Wind Energy: Wind energy: Types of wind turbines, performance analysis, site selection, and applications;

Ocean energy: wave energy, tidal energy, ocean thermal energy conversion (OTEC); Design considerations and environmental aspects.

Tidal Energy: Tides and waves as energy suppliers and their mechanics; fundamental characteristics of tidal power, harnessing tidal energy, advantages and limitations.

UNIT 4 **(06 Hrs)**

Biomass Energy: Biomass: sources, conversion technologies (gasification, pyrolysis, combustion); Biogas production and applications;

Geothermal energy: Resources, types of systems, and power generation.

TEXT AND REFERENCE BOOKS

1. Rai, G.D., *Nonconventional Energy Sources*, 4th Edition, Khanna Publishers, 2018.
2. Rao, S. and Parulekar, B.B., *Energy Technology*, 2nd Edition, Khanna Publishers, 2004.
3. Sukhatme, S.P., *Solar Energy*, 2nd Edition, Tata McGraw-Hill, 1996.
4. Culp, A.W. Jr., *Principles of Energy Conversion*, 3rd Edition, McGraw-Hill, 1996.
5. Singh, S.N., *Non-Conventional Energy Resources*, 1st Edition, Pearson, 2018.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	-	-	-	-	-	-	-	-	-	-	3
CO2	3	-	-	-	-	-	-	-	-	-	-	3
CO3	3	-	-	3	-	-	-	-	-	-	-	2
CO4	3	-	-	-	-	3	3	-	-	-	-	2

CT-317	Upstream Processing for Bioprocesses	L-T-P: 3-0-0	3 Credits	PEC-1(4)

Pre-requisites: None

COURSE OBJECTIVES

To learn about the principles of upstream processing for conducting fermentation in lab and industrial scale.

COURSE OUTCOMES

After completion of the course students will be able to:

1. To understand the concepts of microbial cells, types, cell organelles, identification and their nomenclature.
2. Students will learn the cultivation of microorganism, preparation of media, cell preservation, media optimization and pure culture techniques.
3. To understand the inoculum development process, its criteria, and aseptic inoculation procedures.
4. To understand the sterilization of media and fermenters also designing of media sterilizers.

COURSE CONTENT

UNIT 1 **(08 Hrs)**

The cellular basis of life, cell theory and cell as the basic unit of life; Structure and characteristics of prokaryotic and eukaryotic cells; Plant cell and animal cell; Cell organelles - Structure and functions; Microorganisms: Classification, characterization, identification, and nomenclature.

UNIT 2 **(14 Hrs)**

Cultivation of microorganisms; Types of media, simple and complex media; Medium formulation and optimization: carbon sources, nitrogen sources, minerals, vitamins and other nutrients, precursors, inducers, chelators, growth factors, and antifoams; Pure culture techniques-microbes isolation, identification and maintenance of cultures, preservation techniques, characteristics of pure culture, strain improvement; Genetically engineered cells.

UNIT 3 **(08 Hrs)**

Inoculum development, criteria for inoculum transfer, development for inoculum for bacteria, fungi, animal cells processes; Aseptic inoculation of plant fermenters.

UNIT 4 **(12 Hrs)**

Media sterilization; kinetics of thermal death of cells & spores, design of batch and continuous thermal sterilization; Sterilization of air: Methods & Mechanism, design of depth filter and estimation of its efficiency; Achievement and maintenance of aseptic conditions: Sterilization of fermenter, air supply, and exhaust gases from fermenter, addition of inoculum, nutrients and other supplements, sampling, feed ports, sensor probes, foam control.

TEXT AND REFERENCE BOOKS

1. Pelczar, M.J. Jr., Chan, E.C.S., and Krieg, N.R., *Microbiology*, 5th Edition, Tata McGraw-Hill Book Company, 2008.
2. Stanbury, P.F., Whitaker, A., and Hall, S.J., *Principles of Fermentation Technology*, 3rd Edition, Aditya Books Pvt. Ltd., 2017.
3. Peppler, H.J., and Perlman, D., (Eds.), *Microbial Technology*, Volume II, Academic Press, New York, 2014.
4. Prescott, S.C., and Dunn, C.G., *Industrial Microbiology*, 4th Edition, McGraw-Hill Book Company, New York, 2004.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)

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

SIXTH SEMESTER

Sl.	Paper ID	Course Code	Course Name	Category Code	Basic / Honours	Contact L – T - P	Credits
1		CT-302	Transport Phenomena	PCC-17	B	4 – 0 – 0	4
2		CT-304	Process Modelling & Simulation	PCC-18	B	4 – 0 – 0	4
3		CT-306	Process Equipment Design	PCC-19	B	4 – 0 – 0	4
4		CT-308	Fuels and Combustion	PCC-20	B	3 – 0 – 0	3
5			**Elective - II**	**PEC-2**	**B**	**3 – 0 – 0**	**3**
		MOOCs – 5	**Equivalent course from *MOOCs/Swayam#***				
6		CT-352	Fuel Technology Lab	SEC-10	B	0 – 0 – 3	2
7		CT-354	Process Modelling & Simulation Lab	SEC-11	B	0 – 0 – 3	2
8		CT-356	Seminar-II	AEC-6	B	0 – 0 – 3	2
			Total			**27**	**24**

Elective-II List:

Sl.	Paper ID	Course Code	Course Name
1		CT-310	Multiphase Reactor
2		CT-312	Water Pollution and Abatement
3		CT-314	Energy Audit for Process Industries
4		CT-316	Biological Reactors

CT-302	Transport Phenomena	L-T-P: 4-0-0	4 Credits	PCC-17

Pre-requisites: CT-203, CT-207 & CT-202

COURSE OBJECTIVES

To be able to analyze various transport processes with understanding of basic principles, method of solution and their limitations.

COURSE OUTCOMES

At the end of the course, the student should be able to:

1. Understand the basic principles of mass, energy and momentum transfer and their applications.
2. Derive the fundamental transport equations that govern mass, heat and momentum transfer and associated initial and boundary conditions.
3. Formulate and solve analytically the steady and time dependent flow/heat/mass transfer problems either individually or coupled for simple geometries.
4. Analyze industrial problems along with appropriate approximations and boundary conditions.

COURSE CONTENT

UNIT 1: Fundamentals of Transport Phenomena (20 Hrs)

Importance of transport phenomena and analogous nature of transfer process; Basic concepts and conservation of laws; Molecular and convective transport of mass, energy and momentum, newton's law of viscosity; Fourier's law of heat conduction, and Fick's law of diffusion; Transport coefficients – viscosity, thermal conductivity and mass diffusivity.

UNIT 2: The equations of change for isothermal systems (14 Hrs)

The equation of continuity; The equation of motion; The equation of mechanical energy; The equation of angular momentum; The equations of change in terms of the substantial derivative; Application of the equations of change to solve flow problems; Velocity distributions in turbulent flow: Comparisons of laminar and turbulent flows.

UNIT 3: Shell Momentum & Energy Balances (12 Hrs)

Shell momentum balances and boundary conditions; Flow of a falling film, flow through a circular tube, flow through annulus, flow of two adjacent immiscible fluids, creeping flow around a sphere.

Shell energy balances and boundary conditions; Heat conduction with an electrical heat source, heat conduction with a nuclear heat source, heat conduction with a viscous heat source, heat conduction with a chemical heat source, heat conduction through composite walls, heat conduction in a cooling fin, forced convection and free convection.

UNIT 4: Concentration distributions in solids and laminar flow (10 Hrs)

Shell mass balances and boundary conditions; Diffusion through a stagnant gas film; Diffusion with a heterogeneous chemical reaction; Diffusion with a homogeneous chemical reaction; Diffusion into a falling liquid film (gas absorption); Diffusion into a falling liquid film (solid dissolution).

TEXT AND REFERENCE BOOKS

1. Bird, R.B., Stewart, W.E., and Lightfoot, E.N., *Transport Phenomena*, 2nd Edition, John Wiley, 2002.
2. Welty, J.R., Wicks, C.E., Wilson, R.E., and Rorrer, G., *Fundamentals of Momentum, Heat and Mass Transfer*, 5th Edition, John Wiley, New York, 2007.
3. Geankoplis, C.J., *Transport Processes and Unit Operations*, 3rd Edition, Prentice Hall India, 1993.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)

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

CT-304	Process Modelling & Simulation	L-T-P: 4-0-0	4 Credits	PCC-18

Pre-requisites: None

COURSE OBJECTIVES
To provide the basic concept for modelling and simulation of chemical engineering systems and to solve the model equations by applying suitable numerical techniques.

COURSE OUTCOMES
At the end of the course, the student should be able to:
1. Analyse physical and chemical phenomena involved in various chemical process.
2. Understanding the principle of mass, energy and momentum conservation equations.
3. Develop mathematical models for various chemical engineering systems.
4. Concept of chemical process simulators.

COURSE CONTENT
UNIT 1: Mathematical Modelling (12 Hrs)
Models, basis of mathematical model, types of mathematical model, fundamental laws of modelling, model building, modelling difficulties, differential and population balance models, stochastic, empirical models, unit models, application and importance of mathematical models in process design.

UNIT 2: Fundamental laws (18 Hrs)
Continuity equations, energy equations, equation of state, equilibrium, & chemical kinetics; Models of reactors: plug flow, constant and variable holdup CSTRsunder isothermal and non-isothermal conditions, batch etc, one dimensional and two-dimensional fixed bed reactor models, fluidized bed reactor models; Model of mass transfer: ideal binary distillation column and non-ideal multi-component distillation column, batch distillation with holdup etc, single component vaporizer, multi-component flash drum, absorption column, gravity flow tank, heat transfer models: Evaporators, heat transfer in a bar, heat exchangers.

UNIT 3: Application of numerical methods in digital simulation (14 Hrs)
Interactive convergence methods, newton Raphson method, explicit convergence method, Euler method, Runge-Kutta method, Implicit method, stability analysis of ODEs and estimation optimal step size, numerical solution for initial value problems and boundary value problems; Numerical solution for partial differential equations.

UNIT 4: Process flow simulation (12 Hrs)
Steady state simulation, concept of unit computation, block diagrams development, signal flow graph, partition, tearing convergence block and control block concept, process matrices, identification of recycle sets through process matrices; introduction to professional simulation software.

TEXT AND REFERENCE BOOKS

1. Luyben, W.L., *Process Modelling, Simulation and Control for Chemical Engineers*, 2nd Edition, McGraw Hill Education Pvt. Ltd., 1990.
2. Ray, A.K. and Gupta, S.K., *Mathematical Methods in Chemical & Environmental Engineering*, 1st Edition, Thomson Learning, 2004.
3. Asgher, Hussain, *Chemical Process Simulation*, 1st Edition, Wiley Eastern Ltd., New Delhi, 1994.
4. Babu, B.V., *Process Plant Simulation*, 1st Edition, Oxford University Press, 2004.
5. Franks, R.G.E., *Modelling and Simulation in Chemical Engineering*, 1st Edition, Wiley InterScience, 1972.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	-	-	3	-	-	-	-	-
CO2	3	3	3	3	-	-	3	-	-	-	-	-
CO3	3	3	3	3	-	-	3	-	-	-	-	-
CO4	3	3	3	3	-	-	3	-	-	-	-	-

CT-306	Process Equipment Design	L-T-P: 4-0-0	4 Credits	PCC-19

Pre-requisites: None

COURSE OBJECTIVES

Understand design principles of heat & mass transfer equipment used in chemical plants.

COURSE OUTCOMES

After completion of the course students will be able to:

1. Apply industrial codes to equipment sizing.
2. Perform thickness, heat, and mass transfer calculations
3. Produce engineering drawings and equipment datasheets.
4. Design shell-and-tube exchangers, columns, and pressure vessels per process specification.

COURSE CONTENT

UNIT 1: Introduction to Process Equipment Design (11 Hrs)

Importance and scope of equipment design in chemical industries; Role of standards and codes: IS, ASME, API, TEMA; Classification of equipment; Steps in equipment design: Process design, mechanical design, and drafting; Criteria for material selection and material of construction; Operating vs design conditions; Design pressure and temperature; Corrosion and erosion allowances; Factor of safety; Stress analysis; Types of loads: static, dynamic, thermal, wind, seismic.

UNIT 2: Design of Pressure Vessels (15 Hrs)

Thickness calculations for cylindrical/spherical shells under internal and external pressure; Theories of failure; Design of supports (Saddle and bracket); Design of heads (flat, ellipsoidal, hemispherical, conical etc.); Nozzle and flange design; Reinforcement pads; Gasket types and selection.

UNIT 3: Designing of Shell and Tube Heat Exchangers (15 Hrs)

Classification, configurations, and components of shell-and-tube exchangers; TEMA and ASME standards; LMTD, NTU, Kern's and Bell–Delaware Method for heat exchanger design; Determination of pressure drop, sizing, tubes, tube sheets, baffles, tube bundle, etc.

UNIT 4: Design of Packed Column (15 Hrs)

Design basis: Column diameter based on flooding velocity; Empirical correlations (Sherwood, Fair); Generalized pressure drop correlation (GPDC charts); Height calculation using HTU-NTU or HETP methods; Packing factor and effective interfacial area.

TEXT AND REFERENCE BOOKS

1. Bhattacharya, B.C., *Introduction to Chemical Equipment Design*, CBS Publishers, 2003.
2. Brownell, L.E. and Young, H.E., *Process Equipment Design*, John Wiley, 2004.
3. Indian Standard IS:2825–1969, *Code for Unfired Pressure Vessels*, Reaffirmed 2022.
4. Kern, D.Q.,*Process Heat Transfer*, McGraw Hill Book Co. Inc., 1982.
5. Mahajani, V.V. and Umarji, S.B., *Joshi's Process Equipment Design*, Laxmi Publications Pvt. Ltd., 2016.
6. Moss, D.R., *Pressure Vessel Design Manual*, 4th Edition, Gulf Publishing, 2013.

Course outcomes (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	2	-	-	-	-	-	-	1
CO2	3	2	3	3	1	-	-	-	-	-	-	1
CO3	2	3	3	3	1	-	-	-	-	3	-	-
CO4	3	3	3	3	1	-	-	-	-	-	-	2

CT-308	Fuels and Combustion	L-T-P: 3-0-0	3 Credits	PCC-20

Pre-requisites: None

COURSE OBJECTIVES

To provide in-depth knowledge of conventional and non-conventional fuels, their properties, processing, utilization, and environmental implications in the context of chemical engineering.

COURSE OUTCOMES

1. Identify and classify various types of fuels and their properties.
2. Understand the processes involved in coal carbonization, gasification, and liquefaction.
3. Evaluate combustion processes and calculate calorific values and efficiencies.
4. To study alternate fuels, renewable energy sources, and their significance in sustainable development.

COURSE CONTENT

UNIT 1: Introduction to fuels and classification (06 Hrs)

Definition, types, and classification of fuels (solid, liquid, gaseous); Characteristics of good fuel; Proximate and ultimate analysis of coal; Heating values: Higher and lower calorific values.

UNIT 2: Solid Fuels (12 Hrs)

Origin and classification of coal; Coal preparation, washing, and blending; Coal carbonization: High and low temperature carbonization; Manufacture of coke: Otto-Hoffmann oven; Coal gasification: Lurgi and Winkler processes; Coal liquefaction (Bergius and Fischer-Tropsch processes);Applications in industry.

UNIT 3: Liquid Fuels (12 Hrs)

Origin, composition, and classification of crude oil; Petroleum refining: Distillation (atmospheric & vacuum), cracking (thermal & catalytic); Reforming, polymerization, alkylation, isomerization; Products of petroleum: gasoline, diesel, kerosene; Fuel quality parameters: Octane and cetane numbers, flash point, fire point and other important properties; Additives and blending.

Alternative Fuels: Introduction to renewable energy sources: Biofuels, hydrogen, solar fuels, alcohol fuels; Environmental effects of fuel usage: SOx, NOx, CO_2, and particulate matter; Energy conservation and sustainable practices; Government policies and global trends in energy and fuel usage.

UNIT 4: Gaseous Fuels and Combustion (12 Hrs)

Natural gas, producer gas, water gas, coal gas, LPG, CNG; Properties, advantages, and limitations;

Combustion chemistry of fuels; Air-fuel ratio, stoichiometric calculations; Flue gas analysis using ORSAT apparatus; Calorific value estimation and combustion efficiency; Environmental impacts of combustion.

TEXT AND REFERENCE BOOKS

1. Sarkar, S., *Fuels and Combustion*, 3rd Edition, CRC Press, 2010.
2. Turns, S. R., *An Introduction to Combustion: Concepts and Applications*, McGraw-Hill, 2011.
3. Mukunda, H. S., *Understanding Combustion*, 2nd Edition, Universities Press, 2009.
4. Gupta, O. P., *Elements of Fuel & Combustion Technology*, 1st Edition, Khanna Publishers, 2018.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	-	-	2	-	3	2	-	3	-	-	3
CO2	3	-	-	2	-	3	2	-	3	-	-	3
CO3	3	-	-	2	-	3	2	-	3	-	-	3
CO4	3	-	-	2	-	1	2	-	3	-	-	3

CT-352	Fuel Technology Lab	L-T-P: 0-0-3	2 Credits	SEC-10

Pre-requisites:

COURSE OBJECTIVE

1. To provide practical exposure to the testing and analysis of fuels.
2. To determine the physical and chemical properties of solid, liquid, and gaseous fuels.
3. To impart knowledge on the combustion characteristics and calorific values of different fuels.

COURSE OUTCOMES

After completion of the course students will be able to:

1. Analyze and interpret various properties of coal, petroleum products, and gaseous fuels.
2. Evaluate the calorific value of solid, liquid, and gaseous fuels using standard equipment.
3. Conduct experiments related to fuel ignition, combustion behavior, and fuel efficiency.
4. Prepare systematic laboratory reports and demonstrate understanding of fuel quality control and safety.

LIST OF EXPERIMENTS

1. **Proximate analysis** of coal (moisture, volatile matter, ash, fixed carbon).
2. **Ultimate analysis** of coal (carbon, hydrogen, nitrogen, sulfur content).
3. **Determination of calorific value** of solid and liquid fuels using Bomb Calorimeter.
4. **Flash and fire point** determination of liquid fuels.
5. **Viscosity measurement** of lubricating oils.
6. **Penetration test** for bitumen.
7. **Softening point** and **ductility test** of bituminous material.
8. **Smoke point** and **carbon residue** of liquid fuels.
9. **Ash content** and **sulfur content** analysis in fuels.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	2	2	1	1	-	-	-	-	1	-	2
CO2	3	3	2	2	1	-	-	-	-	1	-	2
CO3	2	1	3	2	2	-	1	-	-	2	-	3
CO4	2	1	2	2	-	-	-	-	1	3	1	2

CT-354	Process Modelling and Simulation Lab	L-T-P: 0-0-3	2 Credits	SEC-11

Pre-requisites:

COURSE OBJECTIVE

1. To introduce students to the concepts of process modelling using equations and simulations.
2. To enable students to build and simulate chemical process systems using professional software.
3. To familiarize students with steady-state and dynamic behaviour of chemical processes.

COURSE OUTCOMES

After completion of the course students will be able to:

1. Understand the fundamentals of process modelling and the role of simulation in chemical process industries.
2. Apply mass and energy balances to model various unit operations.
3. Use commercial software (e.g., Aspen Plus, DWSIM, MATLAB/Simulink) to simulate chemical processes.
4. Analyse simulation results and optimize process variables for better performance.

LIST OF EXPERIMENTS

1. **Introduction to Process Simulation Software**: Basic interface, unit setup, and data input.
2. **Modelling of a Mixer/Splitter**: Mass balance calculations and simulation.
3. **Flash Drum Simulation**: Vapour-liquid equilibrium and energy balance.
4. **Simulation of Distillation Column**: Binary separation under steady-state conditions.
5. **Simulation of Heat Exchanger**: Counter-current and co-current flow models.
6. **CSTR Simulation**: Isothermal and non-isothermal operation.
7. **Plug Flow Reactor (PFR) Modelling**: Kinetic and thermodynamic inputs.
8. **Reactor Network Modelling**: Multiple reactors in series and parallel.
9. **Dynamic Simulation** of process start-up and shut-down (optional for advanced learners).
10. **Process Optimization** using sensitivity analysis tools in simulation software.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	2	3	-	-	-	-	1	-	2
CO2	3	3	2	3	2	-	-	-	-	1	-	2
CO3	3	3	3	3	3	-	-	-	2	2	2	3
CO4	2	2	3	3	3	2	1	-	2	3	1	2

CT-356	Seminar - II	L-T-P: 0-0-3	2 Credits	AEC-6

Pre-requisites: None

COURSE OBJECTIVES

1. To develop students' skills in literature review, technical writing, and oral communication.
2. To expose students to recent developments, challenges, and innovations in Chemical Engineering and allied fields.
3. To encourage self-learning, critical thinking, and confidence in presenting technical topics.
4. To provide a platform to improve research aptitude and academic ethic.

COURSE OUTCOMES

1. Identify and research a recent or relevant topic in Chemical Engineering or a multidisciplinary area.
2. Review and synthesize scientific literature and technical reports effectively.
3. Deliver a structured technical seminar using effective presentation tools and techniques.
4. Demonstrate academic ethics, confidence, and critical thinking during oral presentation and discussion.

COURSE REQUIREMENTS

1. Each student shall choose a topic of interest (preferably interdisciplinary or emerging).
2. Topic must be approved by a faculty coordinator.
3. The student shall prepare a **technical report**, give an **oral presentation**, and participate in a **Q&A session**.
4. Marks will be awarded based on:
   a) Topic relevance and originality
   b) Quality of content and literature review
   c) Presentation skills
   d) Report writing and formatting
   e) Ability to answer questions

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	2	3	3	3	2	2	-	2	2	-	2
CO2	3	3	2	2	3	3	-	-	2	2	-	2
CO3	2	-	-	-	3	-	-	-	2	2	3	-
CO4	2	2	2	2	-	2	3	-	2	2	3	3

CT-310	Multiphase Reactors	L-T-P: 3-0-0	3 Credits	PEC-2(1)

Pre-requisites: None

COURSE OBJECTIVES

To learn general theory of multiphase reactions in a multiphase reactor and their functioning, advantages, disadvantages and challenges along with future direction for research.

COURSE OUTCOMES

After completion of the course students will be able to:

1. To understand the general theory of multiphase reactions.
2. Basic concepts of modelling of continuous integral reactors and semi-batch reactors.
3. To understand the dynamics of multiphase reactors.
4. To understand the functioning of Trickle bed reactors, Bubble Column, Slurry Reactor and three phase fluidized bed reactors.

COURSE CONTENT

UNIT 1: Introduction and General Theory of Multiphase Reactions (10 Hrs)

Introduction: Types of multiphase reactors, comparison of different types of multiphase reactors;
Kinetic models in three phase systems: Langmuir Hinshelwood Model and Power Law model; Analysis of differential reactors, zero order reactions, Reversible reactions, Analysis of some special problems.

UNIT 2: Modelling of Reactors (10 Hrs)

Modelling of continuous integral reactors: Pseudo-First order reactions, Non-linear Kinetics and Reaction of two gases in three phase reactors; Modelling of semi-batch reactor: First order reaction; Analysis of mth order reactions; Analysis of some complex effects: Effect of solubility, temperature and significant product adsorption; Modelling of some multi-step reactions.

UNIT 3: Dynamics of Multiphase Systems (10 Hrs)

Introduction and general Concepts, Dynamics of three phase semi-batch adsorbers: Linear and Non-linear adsorption isotherm; Fixed bed systems: Volatile and Nonvolatile tracers; Dynamics of three phase reactors.

UNIT 4: Examples of Multiphase Reactors (12 Hrs)

Trickle Bed Reactors: Flow regimes, pressure drop, liquid holdup Bubble Column slurry reactor: Flow regimes and gas holdup; Three phase fluidized bed reactors: flow regimes, gas and liquid holdup and Bubble diameter.

TEXT AND REFERENCE BOOKS

1. Ramachandran, P.A., and Chaudhary, R.V., *Three Phase Catalytic Reactors*, Gordon and Breach Science Publishers, 1992.
2. Pangarkar, V.G., *Design of Multiphase Reactors*, John Wiley and Sons, 2014.
3. Jakobsen, H.A., C*hemical Reactor Modelling: Multiphase Reactive Flows*, Springer 2nd Edition, 2014.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	-	-	-	3	-	-	-	-	-	-	3
CO2	3	-	-	-	-	-	-	-	-	-	-	2
CO3	3	3	-	-	-	-	-	-	-	-	-	3
CO4	3	-	3	-	-	-	-	-	-	-	-	2

CT-312	Water Pollution and Abatement	L-T-P: 3-0-0	3 Credits	PEC-2(2)

Pre-requisites: None

COURSE OBJECTIVES

To introduce students to water pollution sources, water quality parameters, and essential treatment methods for effective and sustainable water and wastewater management.

COURSE OUTCOMES

After completing the course, students will be able to;

1. Analyze water and wastewater quality based on standard parameters.
2. Identify pollution sources and their environmental effects.
3. Explain primary, secondary, and tertiary treatment processes.
4. Select appropriate treatment methods for various water pollution scenarios.

COURSE CONTENT

UNIT 1: Water characteristics, sources, and pollution overview (05 Hrs)

Water quality parameters: pH, DO, BOD, COD, turbidity, TDS, hardness, nutrients, pathogens; Sampling and preservation methods; Sources of pollution: domestic, industrial, agricultural; point vs non-point; Effects of pollution on health and environment; National and international water quality standards (IS:10500, WHO); Environmental regulations: Water Act 1974, EPA 1986.

UNIT 2: Primary treatment techniques (10 Hrs)

Classification; Screening (coarse and fine); Grit chamber; Sedimentation (plain and chemical-aided); Flow equalization; Coagulation and flocculation (with design principles).

UNIT 3: Secondary treatment techniques (15 Hrs)

Classification; Aerobic process; Activated sludge process (ASP); Trickling filters; Rotating biological contactors (RBC); Oxidation ponds and lagoons; Anaerobic process; Septic tanks; Anaerobic digesters; Upflow anaerobic sludge blanket reactors (UASB); Concept of MLSS, F/M ratio, sludge age etc.

UNIT 4: Tertiary and advanced treatment techniques (12 Hrs)

Types of advanced treatment techniques; Disinfection methods; Chlorination; UV; Ozonation; Nutrient removal; Nitrification–Denitrification; phosphorus precipitation; Filtration techniques; Sand, dual media, membrane filtration (MF, UF, NF, RO); Advanced oxidation processes (AOPs); O_3/H_2O_2; Fenton; UV/H_2O_2; Water reuse and recycling strategies.

TEXT AND REFERENCE BOOKS

1. Metcalf & Eddy, *Wastewater Engineering: Treatment and Resource Recovery*, 5th Edition, McGraw-Hill Education, 2014.
2. Garg, S.K., *Water Supply Engineering and Wastewater Engineering (Vol. I & II)*, 32nd Edition, Khanna Publishers, 2022.
3. Rao, M.N. and Rao, H.V.N., *Air and Water Pollution Control Engineering*, 2nd Edition, McGraw-Hill Education, 2007.
4. Fair, G.M., Geyer, J.C., and Okun, D.A., *Water and Wastewater Engineering*, Reprint Edition, John Wiley / CBS Publishers (India), 2010.
5. CPHEEO, *Manual on Sewerage and Sewage Treatment Systems*, 2nd Edition, Central Public Health and Environmental Engineering Organization, 2013.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	2	3	-	-	-	-	1	1	-	-	-	3
CO2	3	2	1	-	-	1	1	1	-	-	-	3
CO3	3	1	1	1	-	2	2	1	-	-	-	3
CO4	3	1	1	1	-	3	2	1	2	-	-	3

CT-314	Energy Audit for Process Industries	L-T-P: 3-0-0	3 Credits	PEC-2(3)

Pre-requisites: None

COURSE OBJECTIVES
The course is designed with an objective to make student understand the energy audit in industries.

COURSE OUTCOMES
After completion of the course students will be able to:
1. Understand the demand and gaps in energy sectors, its conservation and audit procedure in industries.
2. Understand the concepts of energy and electrical system performance.
3. Understand the concepts of energy and thermal system performance.
4. understand aspects of various industries.

COURSE CONTENT
UNIT 1: Energy scenario (15 Hrs)
Energy conservation act 2001, basics of energy and its various forms; Energy management and audit, material and energy balance; Energy Action planning; Financial management, Project Management; Energy monitoring and targeting; Energy efficiency; New and renewable energy sources.

UNIT 2: Electrical system performance assessment (10 Hrs)
Electrical system, electric motors, compressed air system, HVAc and refrigeration system; Fans and blowers; Pumps and pumping system, and Cooling tower.

UNIT 3: Thermal systems performance assessment: (10 Hrs)
Fuels and combustion; Boilers, steam system, furnaces, insulation and refractories; FBC boilers; cogeneration and waste heat recovery.

UNIT 4: Case studies of various industries (07 Hrs)
Thermal power station; Steel industry; Cement industry and Fertilizer industry.

TEXT AND REFERENCE BOOKS

1. Aparnathi, R., *Industrial Energy Audit: Study and Approach of Energy Audit and Conservation in Industrial Area*, 1st Edition, LAP LAMBERT Academic Publishing, 2020.
2. Gabbar, H.A., *Energy Conservation in Residential, Commercial and Industrial Facilities*, 1st Edition, IEEE Press Series, 2018.
3. Rajan, G.G., *Optimizing Energy Efficiencies in Industry*, 1st Edition, Tata McGraw-Hill Publishing Co., 2002.
4. TERI, *Handbook on Energy Audit and Environment Management*, 1st Edition, TERI Bookstore, 2006.
5. Witte, L.C., Schmidt, P.S., and Brown, D.R., *Industrial Energy Management and Utilization*, 1st Edition, Hemisphere Publishing, Washington, 1988.
6. Thumann, A. and Younger, W.J., *Handbook of Energy Audits*, 8th Edition, CRC Press, 2008.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	3	3	1	2	3	-	3	2	2	1
CO2	3	3	3	3	2	2	3	-	3	-	3	2
CO3	3	3	3	3	1	2	3	-	3	-	3	2
CO4	3	3	3	3	1	3	3	-	3	-	3	2

CT-316	Biological Reactors	L-T-P: 3-0-0	3 Credits	PEC-2(4)

Pre-requisites: None

COURSE OBJECTIVES

To learn the design and analysis of bioreactors used for plant operations in biochemical and wastewater treatment.

COURSE OUTCOMES

1. Concept of biological system and the bioreactors along with various parts of the bioreactor assembly and their functions.
2. To understand the sterilization of bioreactors and their assembly, in-situ sterilization, Batch and continuous sterilization for laboratory and industrial bioreactors
3. To get knowledge of bioreactors used for immobilized biocatalysts, plants and Animal Cells cultivations, and microalgae cultivation.
4. To understand the importance of biological reactors in wastewater treatment and production of value- added products.

COURSE CONTENT

UNIT 1: Bioreactors **(12 Hrs)**

Mechanical and nonmechanical agitated bioreactors**,** Different parts of the bioreactor and their functions. Growth models for different cells types. Critical parameters to control during fermentation.

Ideal and non-ideal Bioreactors: kinetics in batch, continuous and fed batch reactors, continuous stirred tank and plug flow or tubular reactors, continuous stirred reactor with cell recycle, and also along with wall growth. Dynamic models, stability, mixing time in agitated tank batch reactor, residence time, and models for nonideal reactors.

UNIT 2: Sterilization & Immobilised Biocatalysts **(08 Hrs)**

Sterilization: Kinetics in batch and continuous sterilization of laboratory and industrial bioreactors and Aseptic techniques for operations of bioreactors.

Immobilised biocatalysts: Immobilised cell catalysts, immobilized enzyme catalysts, Industrial applications case studies.

UNIT 3: Multiphase bioreactors **(10 Hrs)**

Conversion of heterogeneous substrates, Packed bed reactors, Bubble column bioreactor, Fluidised bed bioreactors, Trickle bed bioreactors, Rotating biological reactors, and other alternative reactor configurations.

Bioreactors for animal, plant and microalgae cells: Environmental requirements for Animal, plant and microalgae Cells cultivation, Air lift bioreactors, Perfusion bioreactor, Hollow fibre bioreactors, and other alternative reactor configurations for laboratory and industrial bioreactors.

UNIT 4: Bioreactors for wastewater treatment **(12 Hrs)**

Microbial community diversity in a waste water treatment plant, biological reactors used for removal of phosphate, nitrate, heavy metals, and organic carbonaceous present in wastewater, anaerobic digesters and reactors used for hydrogen and methane production, Case studies on Upflow anaerobic sludge blanket reactors and expanded bed bioreactors.

TEXT AND REFERENCE BOOKS

1. Bailey, J.E. and Ollis, D.F., *Biochemical Engineering Fundamentals*, 2ndEdition, Tata McGraw-Hill Education Pvt. Ltd., New Delhi, 2010.
2. Shuler, M.L. and Kargi, F., *Bioprocess Engineering: Basic Concepts*, 2ndEdition, Prentice Hall of India, New Delhi, 2005.
3. Lee, J.M., *Biochemical Engineering*, 1st Edition, Prentice Hall International Series in the Physical and Chemical Engineering Sciences, 1992.
4. Stanbury, P.F., Whitaker, A. and Hall, S.J., *Principles of Fermentation Technology*, 2ndEdition, Elsevier, New Delhi, 1995.
1. Shah, M.P. and Couto, S.R., *Wastewater Treatment Reactors: Microbial Community Structure*, 1st Edition, Elsevier, 2021..

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	3	2	1	2	2	2	2	2	2	3
CO2	3	3	3	2	1	2	2	2	2	2	2	3
CO3	3	3	3	3	3	3	3	2	2	3	3	3
CO4	3	3	3	3	3	3	3	2	2	3	3	3

SEVENTH SEMESTER

Sl.	Paper ID	Course Code	Course Name	Category Code	Basic / Honours	Contact L – T - P	Credits
1		CT-401	Mathematical Methods in Chemical Engineering	PCC-21	H	4 – 0 – 0	4
2		CT-403	Chemical Process Safety & Risk Management	PCC-22	H	4 – 0 – 0	4
3		CT-405	Chemical Process Engineering and Economics	PCC-23	H	4 – 0 – 0	4
4			Elective - III	PEC-3	B	3 – 0 – 0	3
		MOOCs – 6	Equivalent course from *MOOCs/Swayam#*				
5			Elective – IV	PEC-4	B	3 – 0 – 0	3
		MOOCs – 5	Equivalent course from *MOOCs/Swayam#*				
6		CT-451	Summer Training/Project##	SEC-12	B	0 – 0 – 0	2
7		CT-453	Minor Project	PW-1	B	0 – 0 – 12	6
			Total			**30**	**26**

Elective-III List:

Sl.	Paper ID	Course Code	Course Name
1		CT-407	Statistical Analysis of Process Data
2		CT-409	Solid Waste Management
3		CT-411	Hydrogen and Fuel Cell
4		CT-413	Industrial Biotechnology

Elective-IV List:

Sl.	Paper ID	Course Code	Course Name
1		CT-415	Introduction to Computational Fluid Dynamics
2		CT-417	Environmental Impact Assessment
3		CT-419	Biosensor and Diagnostic Devices for Healthcare Applications
4		CT-421	Biochemical Processes

CT-401	Mathematical Methods in Chemical Engineering	L-T-P: 4-0-0	4 Credits	PCC-21

Pre-requisites: BS-114, BS-117 & CT-201

COURSE OBJECTIVES

To describe various chemical engineering problems into mathematical form by applying appropriate microscopic and macroscopic balances, and to solve the developed model equations by suitable analytical techniques.

COURSE OUTCOMES

After completion of the course students will be able to:

1. Formulate the physical problems encountered in chemical engineering into mathematical equations.
2. Identify the appropriate analytical solution technique and to solve the model equation.
3. Analyze the results of the different solution techniques.
4. Perform nonlinear analysis.

COURSE CONTENT

UNIT 1 **(18 Hrs)**

Mathematical formulation of chemical engineering problems based on first principles: Classification of mathematical models, mathematical models leading to algebraic equations, ordinary differential equations and partial differential equations. types of chemical engineering problems: Stage-wise operations, steady state and unsteady state diffusion of heat and mass in rectangular and cylindrical geometry; Reaction in continuous stirred tank reactor; Diffusion with reaction; Flow through porous media etc.

UNIT 2 **(14 Hrs)**

Eigenvalues and eigenvectors; Analytical solution of linear algebraic equations, first order homogeneous and non-homogeneous; Ordinary differential equations; Order and degree of differential equations, solution of second order differential equations.

UNIT 3 **(14 Hrs)**

Analytical solution of partial differential equations encountered in chemical engineering problems: Classification of partial differential equations, types of boundary conditions, method of separation of variables, integral method.

UNIT 4 **(10 Hrs)**

Non-linear analysis: Phase plane analysis, bifurcation behavior.

TEXT AND REFERENCE BOOKS

1. Dutta, B.K., *Mathematical Methods in Chemical and Biological Engineering*, 1st Edition, CRC Press, 2017.
2. Jenson, V.G., and Jeffreys, G.V., *Mathematical Methods in Chemical Engineering*, 2nd Edition, Academic Press, 2012.
3. Mickley, H.S., Sherwood, T.K., and Reed, C.E., *Applied Mathematics in Chemical Engineering*, 1st Edition, McGraw Hill, New York, 1957.
4. Pushpavanam, S., *Mathematical Methods in Chemical Engineering*, 1st Edition, PHI Learning, 2002.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	-	-	3	-	-	-	-	-
CO2	3	3	3	3	-	-	3	-	-	-	-	-
CO3	3	3	3	3	-	-	3	-	-	-	-	-
CO4	3	3	3	3	-	-	3	-	-	-	-	-

CT-403	Chemical Process Safety and Risk Management	L-T-P: 4-0-0	4 Credits	PCC-22

Pre-requisites: None

COURSE OBJECTIVES
Equip students with the knowledge to identify, evaluate and control hazards to ensure safety in process plants.

COURSE OUTCOMES
After completion of the course students will be able to:
1. Assess and control industrial hygiene hazards (toxicity, noise, radiation) and understand fire/explosion basics.
2. Conduct hazard identification (Dow Index, HAZOP) and analyze consequences of liquid/vapor releases.
3. Design safety systems and perform risk assessments (event/fault trees).
4. Develop emergency plans and evaluate major chemical accidents for safety improvement.

COURSE CONTENT
UNIT 1: Industrial Hygiene and Safety **(14 Hrs)**
Industrial hygiene and safety aspects: Introduction to industrial hygiene (definition, scope, & importance, types of industrial hygiene hazards: Physical, chemical, biological, ergonomic, exposure routes, monitoring and control techniques)
Toxicology and Radiation Hazards: Principles of toxicology, dose-response relationships, threshold limit values (TLVs), permissible exposure limits (PELs), radiation types, sources, exposure limits, and protective measures);
Noise and Fire/Explosion Hazards: Industrial noise: Sources, measurement, and control, hearing conservation programs, fire triangle and explosion pentagon, flammability limits, flash point, auto-ignition temperature, dust explosions and static electricity hazards.

UNIT 2: Hazard Identification and Ana;ysis **(14 Hrs)**
Hazard identification: Dow Fire and Explosion Index (Dow F&EI); Hazard and Operability Study (HAZOP); Fault tree and Event tree analysis;
Consequence analysis: Flow of liquid/vapour through holes, flashing liquids, pool evaporation.

UNIT 3: Fires, Explosions & Prevention **(16 Hrs)**
Fires and explosions: Introduction; Fire triangle and explosion pentagon; Types of fires: Diffusion flames, premixed flames, flash fires, pool fires, jet fires; Types of explosions: Deflagrations, detonations, BLEVE, dust explosions; Key definitions: Auto-ignition temperature, flammability limits, flash point; Fundamentals of combustion and flame behavior; Flammability and explosibility properties: Flash point, lower and upper flammable limits (LFL/UFL), Minimum Ignition Energy (MIE), Limiting Oxygen Concentration (LOC), Explosion severity parameters: P_{max}, K_{st}, and dP/dt
Design for prevention of fire and explosion: Inerting and purging; Flammability diagram; Explosion suppression systems; Explosion venting and relief systems; Isolation and segregation of flammable materials; Fire and explosion Protection systems: Fire detection and alarm systems, Fire suppression systems (sprinklers, CO_2, foam, dry chemical), Flame arrestors, Emergency Shutdown Systems (ESD)
Relief systems: Introduction to relief systems; Location, types & characteristics.

UNIT 4: Risk Assessment **(12 Hrs)**
Risk assessment techniques: Probability and consequence estimation, Frequency analysis and failure data, Event Tree Analysis (ETA), Fault Tree Analysis (FTA), Layers of Protection Analysis (LOPA)
Emergency Planning: Introduction to Emergency Planning, Elements of an Emergency Plan, On-site and off-site Emergency Planning, Emergency Response and Drills
Case Studies: Bhopal Tragedy, Flixborough Disaster, Mexico City chemical accident.

TEXT AND REFERENCE BOOKS

1. CCPS, *Guidelines for Risk Based Process Safety*, Wiley-AIChE Publication, 2007.
2. CCPS, *Introduction to Process Safety for Undergraduates and Engineers*, Wiley-AIChE Publication, 2016.
3. Crowl, D.A., and Louvar, J.F., *Chemical Process Safety: Fundamentals with Applications*, 3rd Edition, Prentice Hall, 2013.
4. Kletz, T., *Lessons from Disaster: How Organizations Have No Memory and Accidents Recur*, Gulf Publishing, 1993.
5. Lees, F.P., *Loss Prevention in the Process Industries: Hazard Identification, Assessment and Control*, 3rd Edition, Butterworth-Heinemann, 2012.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	-	-	3	-	-	-	-	-
CO2	3	3	3	3	-	-	3	-	-	-	-	-
CO3	3	3	3	3	-	-	3	-	-	-	-	-
CO4	3	3	3	3	-	-	3	-	-	-	-	-

CT-405	Chemical Process Engineering and Economics	L-T-P: 4-0-0	4 Credits	PCC-23

Pre-requisites: None

COURSE OBJECTIVES

Introduce concepts of chemical process engineering and plant economics.

COURSE OUTCOMES

After completion of the course students will be able to:

1. Understanding of concept of process design, & flow sheeting
2. Understand cost estimation and profitability criteria for a chemical process plant.
3. Analyze the batch plant process and their scheduling.
4. Do the heat exchanger integration in a process plant and scale-up of chemical processes.

COURSE CONTENT

UNIT 1 **(12 Hrs)**

Introduction to Process Engineering: Conceptualization and analysis of chemical processes; Chemical process diagrams (BFD, PFD and P&ID), detailed engineering concepts and mapping (startup, construction, site selection and layout); Process flow sheeting and layout considerations; Introduction to utilities and process integration; Selection of materials of construction.

UNIT 2 **(18 Hrs)**

Cost Estimation and Equipment Costing: Types of costs: Capital investment, operating cost, working capital, equipment cost estimation and its methods; Cost indices; Scaling and cost correlations; Economic design criteria, financing the corporate ventures, financial statements, financial reports, financial ratios.

Engineering Economics & Financial Analysis: Time value of money and interest factors; Cash flow diagrams and cash flow estimation; Depreciation methods (Straight Line, MACRS, DDB); Profitability metrics: NPV, IRR, payback period, ROI; break-even analysis; Amortization and depletion; Sensitivity and uncertainly analysis.

Process Design Heuristics: Concept of design heuristics, common chemical process equipment heuristics; Cost estimation using cost equations; Cost capacity relationships and curves.

UNIT 3 **(12 Hrs)**

Introduction to Process Modes: Batch and continuous processing; Time cycle for batch processes; Design and scheduling of batch processes; impact of scale and production volume; Concept of dedicated and multiproduct plant facilities, sizing of vessels in batch plant, inventories.

UNIT 4 **(14 Hrs)**

Efficient utilization of energy; Heat exchanger network design; Separation network design and heuristics; Process trouble shooting and debottlenecking; Ethics and professionalism in process engineering; Salient features of patent literature.

TEXT AND REFERENCE BOOKS

1. Turton, R., Bailie, R.C., Whiting, W.B., and Shaeiwitz, J.A., *Analysis, Synthesis, and Design of Chemical Processes*, 4th Edition, Eastern Economy Edition, 2015.
2. Peters, M.S., and Timmerhaus, K.D., *Plant Design and Economics for Chemical Engineers*, 5th Edition, McGraw Hill, 2017.
3. Smith, R., *Chemical Process Design and Integration*, 2nd Edition, Wiley India, 2006.
4. Couper, J.R., *Process Engineering Economics*, 1st Edition, CRC Press, 2003.
5. Biegler, L.T., Grossmann, I.E., and Westerberg, A.W., *Systematic Methods of Chemical Process Design*, 1st Edition, Prentice Hall International, 1997.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	3	3	3	-	-	-	3	2	2	2
CO2	3	3	3	3	3	-	-	-	3	2	3	3
CO3	3	3	3	3	2	-	3	-	3	2	3	2
CO4	3	3	3	3	3	-	3	-	3	2	2	-

CT-451	Summer Training / Project	L-T-P: 0-0-0	2 Credits	SEC-12

Pre-requisites:

COURSE OBJECTIVE

1. To provide industry exposure and real-world problem-solving experiences to students.
2. To bridge the gap between academic knowledge and industrial applications.
3. To develop soft skills, safety practices, and teamwork abilities in professional settings.
4. To expose students to modern tools, equipment, and processes used in industry/R&D/academia.

COURSE OUTCOMES

After completion of the course students will be able to:

1. Understand the structure, operation, and environment of a chemical process industry or research organization.
2. Apply theoretical knowledge to practical problems in chemical or energy systems.
3. Demonstrate safety practices, process understanding, and professional communication skills.
4. Prepare and present technical reports and presentations summarizing training experiences and learnings.

SUGGESTED AREAS FOR TRAINING

- Chemical or Petrochemical Plants
- Energy and Power Generation Industries
- Environmental or Wastewater Treatment Units
- Cement, Fertilizer, Polymer, or Food Processing Plants
- Research Labs (CSIR, DRDO, BARC, IITs, etc.)
- Startups, MSMEs, or Consultancy Firms
- Academic Projects in Interdisciplinary Areas (AI/ML in process control, sustainability etc.)

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)

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

CT-453	Minor Project	L-T-P: 0-0-12	6 Credits	PW-1

Pre-requisites: None

COURSE OBJECTIVE
1. To develop problem-solving, critical thinking, and project management skills.
2. To integrate knowledge and technical skills acquired during previous semesters.
3. To provide exposure to applied research, design thinking, and/or prototype development.
4. To encourage teamwork, documentation, and technical presentation abilities

COURSE OUTCOMES
After completion of the course students will be able to:
1. Identify a real-world engineering problem and define its scope and objectives
2. Apply appropriate engineering tools, techniques, and principles to solve the problem.
3. Demonstrate the ability to plan, manage time, and work collaboratively.
4. Document and present the project work effectively.

PROJECT GUIDELINES
1. Projects may be individual or team-based (2–4 students).
2. Topics should be interdisciplinary, application-oriented, or research-focused.
3. Areas can include (but are not limited to):
   a. Renewable energy systems
   b. Process simulation or modelling
   c. Pollution control and waste management
   d. Equipment design or optimization
   e. Data analysis using MATLAB/Python/Excel
   f. Fabrication of experimental setups
4. Projects must include:
   a. A clear problem statement
   b. Defined objectives and methodology
   c. Literature survey
   d. Design or modelling/experimental work
   e. Results, discussion, and conclusion
   f. Final project report and presentation

DELIVERABLES
1. Project Proposal
2. Mid-Term Review
3. Final Report **(typed)**
4. Viva-Voce / Presentation

GUIDELINES FOR FEASIBILITY REPORT AND FOR EXPERIMENTAL WORK

Content (for feasibility report)	Content (For experimental work)
Title page with well-defined title; acknowledgment, certificate, Content, List of figure/tables, notations, Abstract	
Chapter 1: Introduction (general introduction, market survey, physical and chemical properties, safety and hazards and uses)	Chapter 1: Introduction
Chapter 2: Process description and election	Chapter 2: Detailed literature review
Chapter 3: Material balance and Energy balance	Chapter 3: Methods/Experimental setup and analysis techniques Chapter 4: Results and discussions (if available)
Spiral bound, Pages- numbered, All heading/ subheading with numbers, References and Appendices.	

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)

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

CT-407	Statistical Analysis of Process Data	L-T-P: 3-0-0	3 Credits	PEC-3(1)

Pre-requisites: None

COURSE OBJECTIVES

To develop an understanding of statistical techniques used in Chemical engineering related to process operations, R&D planning, data analysis, business analytics, and troubleshooting.

COURSE OUTCOMES

After completion of the course students will be able to:

1. Understand the statistical concepts and apply them to analyze data that can assist in the future for troubleshooting and process capability estimation
2. Understand probability models and their impact on process data
3. Perform regression analysis to create models, predict future outcomes, and identify key drivers
4. Develop the ability to identify and solve problems using data-driven insights, leading to more informed decision-making.

COURSE CONTENT

UNIT 1 **(10 Hrs)**

Introduction to statistics: Introduction to statistics: role of statistics in engineering, data measurement, Nominal Level, Ordinal Level, Interval Level, Ratio Level, Comparison of the Four Levels of Data, frequency distributions, Class Midpoint, Relative Frequency, Cumulative Frequency, types of data graphs, quantitative data graphs, Histograms, Frequency Polygons, Ogives, Dot Plots, Stem-and-Leaf Plots, qualitative data graphs, pie chart, bar graph, graphical depiction of two-variable numerical data

UNIT 2 **(10 Hrs)**

Descriptive statistics: measures of central tendency and measures of variability; ungrouped data, grouped data, measures of shape, continuous distributions, uniform distribution, Determining Probabilities in a Uniform Distribution, normal distribution, History of the Normal Distribution, Probability Density Function of the Normal Distribution, Standardized Normal Distribution, Solving Normal Curve Problems, exponential distribution, Probabilities of the ExponentialDistribution

UNIT 3 **(12 Hrs)**

Probability: introduction to probability, methods of assigning probabilities, structure of probability, Classical Method of Assigning Probabilities, Relative Frequency of Occurrence, Subjective Probability, marginal, union, joint, and conditional probabilities, addition laws, Probability Matrices, Complement of a Union, Special Law of Addition, multiplication laws, General Law of Multiplication, Special Law of Multiplication, conditional probability, Independent Events

UNIT 4 **(10 Hrs)**

Simple regression analysis and correlation: Correlation; Introduction to simple regression analysis; Determining the equation of the regression line; Residual analysis; Regression model; Standard error of the estimate, coefficient of determination, estimation, and regression to develop a forecasting trend line.

TEXT AND REFERENCE BOOKS

1. Black, K., *Business Statistics for Contemporary Decision Making*, 7th Edition, John Wiley & Sons, Inc., 2012.
2. DeCoursey, W., *Statistics and Probability for Engineering Applications*, Newnes (Butterworth-Heinemann), 2003.
3. Montgomery, D.C. and Runger, G.C., *Applied Statistics and Probability for Engineers*, 7th Edition, John Wiley, 2018.
4. Ramachandran, K.M. and Tsokos, C.P., *Mathematical Statistics with Applications*, 3rd Edition, Academic Press, 2020.
5. Walpole, R.E., Myers, R.H., Myers, S.L. and Ye, K., *Probability and Statistics for Engineers and Scientists*, 9th Edition, Pearson Education, 2010.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	2	3	3	-	2	-	2	-	3	2
CO2	3	3	2	3	3	-	2	-	3	2	2	2
CO3	3	3	2	2	3	-	1	-	2	-	2	3
CO4	3	3	3	3	3	2	2	-	3	2	3	3

CT-409	Solid Waste Management	L-T-P: 3-0-0	3 Credits	PEC-3(2)

Pre-requisites:None

COURSE OBJECTIVES

To introduce students to the sources, composition, characterization, handling, and sustainable management of solid wastes with an importance on collection, treatment, and disposal techniques.

COURSE OUTCOMES

After completing this course, students will be able to:

1. Identify sources and classify types of solid waste.
2. Analyze physical, chemical, and biological characteristics of solid waste.
3. Explain collection, transport, treatment, and disposal methods.
4. Select appropriate technologies for solid waste minimization and resource recovery.

COURSE CONTENT

UNIT 1 **(07 Hrs)**

Introduction and waste characterization: Definition, scope, and importance of solid waste management; Sources and types of solid waste (municipal, industrial, biomedical, e-waste, hazardous); Waste generation rates; Factors affecting generation; Waste composition: physical, chemical, and biological characteristics; Sampling and analysis methods; Public health and environmental impacts.

UNIT 2 **(05 Hrs)**

Collection, transportation & Storage: Storage methods at source; Primary and secondary collection systems; Tools and equipment; Transfer stations and logistics; Transportation systems and route optimization; Community participation and informal sector involvement.

UNIT 3 **(15 Hrs)**

Waste processing and resource recovery: Processing techniques: manual/mechanical separation, shredding, baling, compaction; Biological processing: composting (aerobic/anaerobic), vermicomposting; Thermal processing: incineration, pyrolysis, gasification; Recovery and recycling of materials (paper, plastic, metals, glass); Energy recovery from waste.

UNIT 4 **(15 Hrs)**

Waste disposal and sustainable practices: Sanitary landfill: design, operation, leachate and gas management, post-closure care; Landfill remediation; Hazardous waste management; Biomedical and e-waste rules and disposal techniques; Integrated solid waste management (ISWM); Policies, regulations (SWM Rules 2016); Life cycle assessment (LCA), 3Rs and circular economy approach.

TEXT AND REFERENCE BOOKS

1. Tchobanoglous, G., Theisen, H., and Vigil, S.A., *Integrated Solid Waste Management: Engineering Principles and Management Issues*, 2nd Edition, McGraw-Hill, 2002.
2. Peavy, H.S., Rowe, D.R., andTchobanoglous, G., *Environmental Engineering*, 1st Edition, McGraw-Hill, 1985.
3. Rao, C.S., *Environmental Pollution Control Engineering*, New Age International, 2022.
4. Bhide, A.D., andSundaresan, B.B., *Solid Waste Management in Developing Countries*, 1st Edition, INSDOC, 1983.
5. Manser, A.G.R. and Keeling, A.A., *Practical Handbook of Processing and Recycling Municipal Waste*, 1st Edition, CRC Press, 1996.
6. Moss, D.R., *Pressure Vessel Design Manual*, 4th Edition, Gulf Publishing, 2013.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	2	-	-	-	-	-	1	1	-	-	3
CO2	3	1	-	-	-	-	-	1	1	-	-	3
CO3	3	1	-	-	1	-	3	2	-	-	1	3
CO4	3	1	-	-	1	-	3	2	-	-	1	3

CT-411	Hydrogen and Fuel Cell	L-T-P: 3-0-0	3 Credits	PEC-3(3)

Pre-requisites: None

COURSE OBJECTIVES

To learn the basics of hydrogen and fuel cells, storage technologies, safety measures, and clean power alternatives for a sustainable future.

COURSE OUTCOMES

After completion of the course students will be able to:

1. The students will able to understand fuel cells applicability and basics.
2. To apply fundamental concept and working of various fuel cells in real worlds applications.
3. Analyses relative advantages / disadvantages and hydrogen generation/storage technologies.
4. Compare and select appropriate hydrogen cell technologies for the various applications.

COURSE CONTENT

UNIT 1 **(16 Hrs)**

Hydrogen Production: Fossil fuels, electrolysis, thermal decomposition, catalytic decomposition, photochemical, photocatalytic, hybrid; Biological processes and limitations.

UNIT 2 **(14 Hrs)**

Fuel Cell: Working principle of fuel cell; Basic-thermodynamics; Reaction kinetics; Charge, and mass transport; Modelling a Fuel Cell; Fuel cell characterization: System and components' characterization; Fuel Cell Technology: Types of Fuel Cells, Fuel cell systems, sub-systems, and their integration; Power management; Thermal management and optimization analysis.

UNIT 3 **(12 Hrs)**

Conventional hydrogen storage methods: Pressure cylinders, liquid hydrogen, metal hydrides, and carbon fibers; Reformer Technologies:Steam reforming, partial oxidation, auto thermal reforming, CO removal; Hydrogen storage materials: Metal-based hydrides and nanostructured metal hydrides.

Non-metal hydrides: Carbohydrates, Amine borane complexes, Imidazolium ionic liquids etc.

Chemical and liquid carriers: Synthesis of hydrocarbons, Aluminum, liquid organic hydrogen carriers (LOHC) and Ammonia; Advanced storage media: Metal-Organic Frameworks (MOFs), Activated carbons, Carbon nanotubes, Clathrate hydrates, Glass capillary arrays, Carbonite substances.

UNIT 4 **(10 Hrs)**

Hydrogen Safety – History of accident, physiological, physical, and chemical hazards; hydrogen properties associated with hazards; Hazard spotting, evaluation, and safety guidelines; Hydrogen safety codes and standards. Hydrogen economy.

TEXT AND REFERENCE BOOKS

1. Dalena, F., Basile, A. and Rossi, C., *Bioenergy Systems for the Future: Prospects for Biofuels and Biohydrogen*, 1st Edition, Elsevier, 2019.
2. Tarascon, J.-M. and Simon, P., *Electrochemical Energy Storage*, Wiley-VCH, 2015.
3. Smil, V., *Energies: An Illustrated Guide to the Biosphere and Civilization*, MIT Press, Cambridge, 1999.
4. Sankir, M. and Sankir, N.D., *Hydrogen Production Technologies*, John Wiley & Sons, 2018.
5. Kerr, J.A., *Introduction to Energy and Climate: Developing A Sustainable Environment*, CRC Press, 2017.
6. Basile, A., Dalena, F., Pedro, C.E.G. and Lau, F., *Advances in Hydrogen Energy*, Springer/IET Publishing, *Hydrogen Production, Separation and Purification for Energy (Energy Engineering) Series*, 2020.
7. Sørensen, B. and Spazzafumo, G., *Hydrogen and Fuel Cells: Emerging Technologies and Applications*, 3rd Edition, Academic Press (Elsevier), 2018.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	1	3	3	2	-	3	-	-	3
CO2	3	3	2	2	2	3	2	-	3	-	-	3
CO3	3	3	3	2	1	2	3	-	3	-	-	3
CO4	3	3	3	2	1	1	1	2	1	-	-	3

CT-413	Industrial Biotechnology	L-T-P: 3-0-0	3 Credits	PEC-3(4)

Pre-requisites: None

COURSE OBJECTIVES

To impart a comprehensive understanding of the biological processes for the production of biochemicals, pharmaceuticals, and industrial products using microbial cell systems.

COURSE OUTCOMES

After completion of the course students will be able to:

1. To understand the concepts of fermentation processes.
2. Students will learn the production of anaerobic fermentation products and various organic acids of industrial importance.
3. Students would be able to learn problems on production of bioproducts in fermentation.
4. To study production of antibiotics, enzymes, polysaccharides, single cell proteins and amino acids

COURSE CONTENT

UNIT 1 **(06 Hrs)**

Introduction to fermentation processes: Submerged, surface and solid state fermentation; Range of fermentation products, primary and secondary metabolites, chronological development of fermentation industry.

UNIT 2 **(12 Hrs)**

Anaerobic fermentation: Fermentative production of ethanol, acetone, butanol, glycerol, beer and wines.
Organic acids fermentation: production of citric acid, gluconic acid, itaconic acid, acetic acid, Lactic acid fermentation, specific lactic starter cultures.

UNIT 3 **(08 Hrs)**

Antibiotic fermentation: Production of penicillin, streptomycin**;**
Microbial production of amino acids: Glutamic acid, lysine;
Production of single-cell protein: bacteria, yeasts including baker's yeast, molds and higher fungi**.**

UNIT 4 **(16 Hrs)**

Production of microbial enzymes: amylases, proteases, lipases.
Microbial production of nucleosides and nucleotides: production of 5'-IMP and 5'-GMP, recombinant cells derived products;
Polysaccharides production: Pullulans, phosphomannan, xanthan gum, dextrans Microbial transformation of steroids; Production of vitamin B12, Riboflavin, carotenoids; Production of bioinsecticides, biofertilizer production, *Rhizobium.*

TEXT AND REFERENCE BOOKS

1. Casida Jr., L.E., *Industrial Microbiology*, 2nd Edition, Wiley Eastern Ltd., 2019.
2. Prescott, S.C., and Dunn, C.G., *Industrial Microbiology*, 4th Edition, McGraw-Hill Book Company, New York, 2004.
3. Peppler, H.J., and Perlman, D. (Eds.), *Microbial Technology*, Volume II, Academic Press, New York, 2014.
4. Crueger, W., and Crueger, A., *Biotechnology: A Textbook of Industrial Microbiology*, 3rd Edition, Sinauer Associates, 2017.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	3	2	-	3	2	-	3	-	-	3
CO2	3	3	3	2	-	3	2	-	3	-	-	3
CO3	3	3	3	2	-	3	2	-	3	-	-	3
CO4	3	3	3	2	-	1	2	-	1	-	-	3

CT-415	Introduction to Computational Fluid Dynamics	L-T-P: 3-0-0	3 Credits	PEC-4(1)

Pre-requisites: None

COURSE OBJECTIVES

To learn the fundamentals and applications of Computational Fluid Dynamics in Chemical Engineering.

COURSE OUTCOMES

1. Improve the student's understanding of basic principles of Computational Fluid Dynamics
2. Ability to translate real-world fluid flow problems into mathematical models appropriate for CFD analysis.
3. Students will have the ability to learn and use modern CFD software tools for solving problems in chemical engineering
4. Improve students' research skills by visualizing and analyzing the results.

COURSE CONTENT

UNIT 1 **(08 Hrs)**

Introduction to CFD: CFD application in Chemical Engineering, Review of Partial differential equations- Parabolic, Hyperbolic and Elliptic equations, Conservation equations, mass, momentum, and energy equations

UNIT 2 **(12 Hrs)**

Principles of Solution of the Governing Equations: Finite difference, Finite element method, and Finite volume Methods, Convergence, Consistency, Error and Stability, Accuracy, Boundary conditions, Mesh generation: Overview of mesh generation, Structured and Unstructured mesh, Guideline on mesh quality and design, Mesh refinement

UNIT 3 **(10 Hrs)**

Solution Algorithms: Discretization schemes for pressure, momentum, and energy equations - Explicit and implicit Schemes, First order upwind scheme, second order upwind scheme, QUICK scheme, SIMPLE, SIMPLER, and PISO algorithm, pressure-velocity coupling algorithms

UNIT 4 **(12 Hrs)**

CFD Solution Procedure: Problem setup, creation of geometry, mesh generation, selection of physics and fluid properties, initialization, solution control and convergence monitoring, results reports and visualization. Case Studies: Benchmarking, validation, Simulation of CFD problems by use of general CFD software, Simulation of coupled heat, mass, and momentum transfer problems.

TEXT AND REFERENCE BOOKS

1. Anderson, J.D., *Computational Fluid Dynamics: The Basics with Applications*, McGraw-Hill Education, 2017.
2. Blazek, J., *Computational Fluid Dynamics: Principles and Applications*, 3rd Edition, Butterworth-Heinemann, 2015.
3. Chapra, S.C., *Applied Numerical Methods with MATLAB for Engineers and Scientists*, 4th Edition, McGraw-Hill, 2017.
4. Ferziger, J.H., and Perić, M., *Computational Methods for Fluid Dynamics*, 4th Edition, Springer International Publishing AG; CBS Publishers & Distributors Pvt. Ltd., 2020.
5. Patankar, S.V., *Numerical Heat Transfer and Fluid Flow*, CRC Press, 2017.
6. Versteeg, H.K., and Malalasekera, W., *An Introduction to Computational Fluid Dynamics: The Finite Volume Method*, 2nd Edition, Pearson Education Limited, 2007.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	3	2	2	-	2	-	2	-	-	3
CO2	3	3	3	2	3	-	2	-	3	-	-	3
CO3	3	3	3	2	3	-	3	-	3	-	-	3
CO4	3	3	3	3	3	-	2	-	2	-	-	3

CT-417	Environmental Impact Assessment	L-T-P: 3-0-0	3 Credits	PEC-4(2)

Pre-requisites: None

COURSE OBJECTIVES

To equip students with basic knowledge of environmental impact assessment, understand legal frameworks, and prepare effective management and mitigation plans.

COURSE OUTCOMES

1. Understand the fundamental concepts, scope, and need for Environmental Impact Assessment (EIA).
2. Apply EIA methodologies to identify, predict, and evaluate environmental impacts of engineering.
3. Apply legal, policy, and regulatory frameworks in environmental planning and project approval.
4. Draft Environmental Management Plans and impact reports with effective communication.

COURSE CONTENT

UNIT 1 **(10 Hrs)**

Introduction to EIA: Definition, scope, and objectives; Historical development; Importance in project planning; Stages of EIA including screening, scoping, baseline data collection, impact analysis, mitigation, reporting, review, and audit; Need for baseline environmental studies.

UNIT 2 **(12 Hrs)**

EIA Methods and Impact Analysis – Methodologies: checklists, matrices (e.g., Leopold), networks, overlays; Prediction and evaluation of air, water, noise, land, and ecological impacts; Use of models and GIS tools; Addressing uncertainties and data gaps.

UNIT 3 **(10 Hrs)**

Environmental Management and Documentation: Mitigation planning; Environmental Management Plan (EMP); Monitoring and auditing; Preparation of Environmental Impact Statement (EIS); Technical writing and report structure; Decision-making support.

UNIT 4 **(10 Hrs)**

Legal and Sectoral Frameworks – Indian EIA regulations (EPA 1986, EIA Notification 2006); Roles of MOEFCC, CPCB, SPCBs; International conventions; Public participation; Case studies from sectors like power, mining, infrastructure, and industry.

TEXT AND REFERENCE BOOKS

1. Canter, L.W., *Environmental Impact Assessment*, 1st Edition, McGraw-Hill, 1996.
2. Glasson, J., Therivel, R. and Chadwick, A., *Introduction to Environmental Impact Assessment*, 4th Edition, Routledge, 2013.
3. Eccleston, C.H., *Environmental Impact Assessment: A Guide to Best Professional Practices*, CRC Press, 2011.
4. Morris, P. and Therivel, R., *Environmental Impact Assessment: Theory and Practice*, 2nd Edition, Routledge, 2009.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	1	-	-	-	-	-	-	-	-	-	3
CO2	1	3	-	-	-	-	-	-	-	-	-	3
CO3	1	1	-	-	-	3	-	-	-	-	-	3
CO4	1	1	1	-	-	-	-	-	-	2	-	3

CT-419	Biosensor and Diagnostic Devices for Healthcare Applications	L-T-P: 3-0-0	3 Credits	PEC-4(3)

Pre-requisites: None

COURSE OBJECTIVES

1. Be able to identify different classes of biosensors and describe their functioning principles and recognize limitations of biosensors in real-life applications
2. Be able to extend engineering principles to biosensor development and to design point-of-care biosensors
3. Understand the principles and concepts of transducers and their application in biosensor design
4. Understand fundamentals of diagnostic devices and biomarker testing in biological fluids

COURSE OUTCOMES

1. Apply basic principles of biology and engineering to design biosensors
2. Apply principles and concepts of electrochemistry to design electrochemical biosensors
3. Recognize different types of functional materials, and their application in biosensor design
4. Apply principles and concepts of sensing and engineering to design biosensors for detection of markers in biofluids

COURSE CONTENT

UNIT 1 **(10 Hrs)**

Introduction to Sensor Architecture: Types of sensors; Components and design; Ideal requirements; Biosensor classification; Main elements in biosensors; Biomolecules in biosensor: DNA, enzyme, antibody, antigen, protein and aptamer; Amplification Techniques (PCR), EISA(enzyme-linked immunosorbent assay).

UNIT 2 **(10 Hrs)**

Basics of Detection Methods: Fluorescence Spectroscopy; UV-Vis Absorption and Emission; Surface Plasmon Resonance; Colorimetry; and Electrochemical detection.

UNIT 3 **(12 Hrs)**

Electrochemical Sensors: Electrochemical detection methods: Redox processes, and electron transfer; Electrochemical cells for measurements; Processes at electrode surface, and mass transport of material to the electrode surface; Active DC electrochemical techniques: voltammetry, amperometry, immobilized enzyme-electrodes; Impedance Spectroscopy; Potentiometry for small molecule and ion detection.

UNIT 4 **(10 Hrs)**

Point-of-care Sensing: Microfluidics and paper-based diagnostics; Yarn and textile-based sensing

TEXT AND REFERENCE BOOKS

1. Moretto, L.M. and Kalcher, K., *Environmental Analysis by Electrochemical Sensors and Biosensors*, Springer, New York, 2015.
2. Yang, V.C. and Ngo, T.T., *Biosensors and their Applications*, Kluwer Academic/Plenum Publishers, New York, 2000.
3. Harsanyi, G., *Sensors in Biomedical Applications: Fundamentals, Technology and Applications*, Technomic Publishing Company, 2000.
4. Hall, E.A., *Biosensors*, Open University Press, Milton Keynes, 1990.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)

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

CT-421	Biochemical Processes	L-T-P: 3-0-0	3 Credits	PEC-4(4)

Pre-requisites: None

COURSE OBJECTIVES
To familiarize the students with principles of Bioseparation technology and to enable students to understand separation of industrially important fermented products.

COURSE OUTCOMES
After completion of the course students will be able to:
1. Learn problems on bioseparation of bioproducts in fermentation.
2. Understand the isolation and purification of bioproducts.
3. Learn problems on recovery of bioproducts in fermentation.
4. Study case studies for purification and polishing of fermented products.

COURSE CONTENT
UNIT 1 **(06 Hrs)**
An overview of Bioseparation, Role of Downstream Processing in Biochemical engineering, Characteristics of byproducts, Problems and requirement of byproduct purification, Cost cutting strategies.

UNIT 2 **(12 Hrs)**
Primary separation and Recovery Process of fermented products, microbial cell disruption methods (Physical, chemical and Enzymatic) for intracellular products. Conditioning of fermented broth, Removal of insoluble, biomass. Separation techniques – Flocculation, Sedimentation, Centrifugation and Filtration at constant pressure and at constant rate.

UNIT 3 **(06 Hrs)**
Microbial product isolation – Extraction and adsorption methods, solid- liquid , liquid –liquid separation, aqueous two phase extraction, membrane based separation -micro and ultrafiltration (theory, design and configuration of the equipment), Precipitation methods- Ammonium sulphate, organic solvents, high molecular weight polymers.

UNIT 4 **(18 Hrs)**
Product Purification: Case studies for using electrophoresis and chromatography process for product purification, different electrophoresis technique –isoelectric focusing, chromatographic technique with special reference to adsorption chromatography, ion- exchange chromatography, gel-filtration chromatography, affinity chromatography, reverse-phase, high pressure liquid chromatography,
hydrophobic chromatography.
Product Polishing: Principles and applications of crystallization, drying (lyophilization, spray drying, vacuum drying, air drying). A Few case studies: Citric acid, Glutamic acid, Penicillin G, Extracellular Enzymes, Intracellular enzymes, Antibodies

TEXT AND REFERENCE BOOKS

1. Ho, W.S.W., and Sirkar, K.K., *Membrane Handbook*, Van Nostrand Reinhold, New York, 1992.
2. Kennedy, J.F., and Cabral, J.M.S., *Recovery Processes for Biological Materials*, Wiley, 1993.
3. Ladisch, M.R., *Bioseparations Engineering*, Wiley-Interscience, 2001.
4. Heinemann, W., *Product Recovery in Bioprocess Technology*, Butterworth Publications, 2004.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	2	-	3	2	-	3	-	-	3
CO2	3	3	3	2	-	3	2	-	3	-	-	3
CO3	3	3	3	2	-	3	2	-	3	-	-	3
CO4	3	3	3	2	-	1	2	-	1	-	-	3

EIGHTH SEMESTER

Sl.	Paper ID	Course Code	Course Name	Category Code	Basic / Honours	Contact L – T - P	Credits
1		CT-402	Industrial Pollution Control	PCC-24	B	3– 0 – 0	3
2		CT-404	Introduction to Biochemical Engineering	PCC-25	B	4 – 0 – 0	4
3		CT-406	Analytical Methods in Engineering	PCC-26	B	3– 0 – 0	3
4		**CT-408**	**Chemical Process Optimization**	**PCC-27**	**H**	**4 – 0 – 0**	**4**
5		CT-450	Analytical Methods in Engineering Lab	PCC-28	B	0 – 0 – 3	2
6		CT-452	Major Project	PW-2	B	0 – 0 – 24	12
			Total			**41**	**28**

CT-402	Industrial Pollution Control	L-T-P: 3-0-0	3 Credits	PCC-24

Pre-requisites: None

COURSE OBJECTIVES

The course focuses on understanding industrial pollution and sustainable methods to minimize it, with an in-depth study of waste treatment and abatement.

COURSE OUTCOMES

After completion of the course students will be able to:

1. Understand industrial pollutants (air, water, and solid) and their relevant standards.
2. Quantify BOD/COD, model oxygen deficit, and manage wastewater effectively.
3. Demonstrate stack sampling for gaseous pollutants and particulate pollutants.
4. Manage solid and hazardous waste through classification, recycling, safe handling, treatment, and disposal

COURSE CONTENT

UNIT 1 **(14 Hrs)**

Different types of wastes generated in an industry and their effect on human health and environment, Types of emissions from chemical industries and their effects; Type of pollution, Sources and characteristics of pollutants in different industries (fertilizer, pharmaceutical, paper and pulp industry, textile, petroleum and petroleum industry, automobile), Environmental regulatory legislations, Effluent guidelines and standards, waste disposal norms.

UNIT 2 **(10 Hrs)**

Water Pollution and Abatement: Sources of water; Oxygen demands and their determination (BOD, COD, and TOC), Oxygen sag curve, BOD curve mathematical, controlling of BOD curve, Characterization and classification of wastewater effluents; Pre-treatment methods; Traditional and Advanced treatment methods; Sludge generation & Optimization

UNIT 3 **(18 Hrs)**

Air Pollution and Abatement: Sources; Types of air pollutants; Atmospheric dispersion: Micrometeorology; Lapse rate; Atmospheric classes; Plume and type of plume; Dispersion models; Ground and elevated sources with and without reflection; Calculation for plume rise and stack gas flow rates.

Air Pollution sampling and measurement: Ambient air sampling: collection of gaseous air pollutants, collection of particulate air pollutants; Stack sampling: Sampling system, particulate sampling, and gaseous sampling; Analysis of air pollutants: Sulphur dioxide, nitrogen oxides, carbon monoxide, oxidants and Ozone, hydrocarbons, particulate matter; Air pollution control methods and equipment.

UNIT 4 **(14 Hrs)**

Solid & Hazardous Waste Management: Classification: industrial, hazardous, biomedical, e-waste; Health and environment effects, Material Recovery & Recycling Techniques; Management approaches: minimization, segregation, recycling, treatment (e.g., pyrolysis, composting), disposal (landfill, incineration); Facility Design; treatment practices in various countries; Regulatory compliance and safe handling protocols

TEXT AND REFERENCE BOOKS

1. Eckenfelder, W. W., *Industrial Water Pollution Control*, 2nd Edition, McGraw-Hill, 1989.
2. Henze, M., *Wastewater Treatment: Biological and Chemical Processes*, Springer Verlag, 1995.
3. Mahajan, S. P., *Pollution Control in Process Industries*, Tata-McGraw Hill, New Delhi, 1985.
4. Rao, C. S., *Environmental Pollution and Control Engineering*, 4th Edition, Revised, New Age International, 2022.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	-	2	-	-	2	-	-	2	-	1
CO2	3	3	-	2	-	-	3	-	-	1	-	2
CO3	3	3	-	2	-	-	2	-	-	2	-	1
CO4	3	3	-	1	-	-	3	-	-	1	-	1

CT-404	Introduction to Biochemical Engineering	L-T-P: 4-0-0	4 Credits	PCC-25

Pre-requisites: None

COURSE OBJECTIVES

To introduce the fundamental principles of biochemical engineering by integrating biology with chemical engineering concepts, enabling students to understand and apply bioprocesses involving enzymes, microorganisms, bioreactors, and downstream processing.

COURSE OUTCOMES

1. To understand the fundamentals of biochemical engineering and the role of microorganisms and enzymes in industrial processes.
2. Analyze enzyme kinetics and apply them to biochemical reaction engineering.
3. Evaluate the design and operation of bioreactors and interpret microbial growth and product formation kinetics.
4. Apply knowledge of downstream processing techniques for the recovery and purification of bioproducts.

COURSE CONTENT

UNIT 1 **(15 Hrs)**

Introduction and scope of biochemical engineering; Interdisciplinary nature: Biology + chemical engineering; Comparison of chemical and biochemical processes; Characteristics of living cells and biomolecules; Industrially important microorganisms; Stoichiometry of microbial growth and product formation.

UNIT 2 **(15 Hrs)**

Introduction to enzymes; Enzyme kinetics: Michaelis–Menten kinetics; Lineweaver–Burk plot;Factors affecting enzyme activity (pH, temperature, inhibitors); Immobilization of enzymes and their industrial applications.

UNIT 3 **(11 Hrs)**

Principles and types of bioreactors; Design and operation of fermenters; aeration and agitation: oxygen transfer, kla; sterilization (media, air, equipment); Scale-up and scale-down issues; Instrumentation and control in bioreactors.

UNIT 4 **(15 Hrs)**

Phases of microbial growth, growth kinetics models; Yield coefficients and specific growth rate; Substrate utilization and product formation kinetics; Cell harvesting (filtration, centrifugation); Cell disruption techniques; Product purification (precipitation, chromatography, extraction); Case studies on industrial bioprocesses.

TEXT AND REFERENCE BOOKS

1. Aiba, S., Humphrey, A.E., and Millis, N.F., *Biochemical Engineering*, 2nd Edition, Academic Press, 1973.
2. Shuler, M.L. and Kargi, F., *Bioprocess Engineering*, 2nd Edition, Prentice Hall of India, 2005.
3. Bailey, J.E. and Ollis, D.F., *Biochemical Engineering Fundamentals*, McGraw-Hill, 1986.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	-	-	2	-	3	2	-	3	-	-	3
CO2	3	-	-	2	-	3	2	-	3	-	-	3
CO3	3	-	-	2	-	3	2	-	3	-	-	3
CO4	3	-	-	2	-	1	2	-	3	-	-	3

CT-406	Analytical Methods in Chemical Engineering	L-T-P: 3-0-0	3 Credits	PCC-26

Pre-requisites: None

COURSE OBJECTIVES

1. To provide a foundation in classical and modern analytical techniques used in chemical and energy engineering.
2. To equip students with knowledge of quantitative and qualitative analysis of materials and products.
3. To develop the ability to select and apply appropriate techniques for process monitoring and quality control.

COURSE OUTCOMES

1. Understand the principles of classical and instrumental analytical techniques.
2. Apply spectroscopic, chromatographic, and electrochemical methods in analysis.
3. Select appropriate analytical techniques for process and quality monitoring.
4. Interpret analytical data and troubleshoot common measurement challenges.

COURSE CONTENT

UNIT 1: Classical Analysis Methods **(10 Hrs)**

Introduction to analytical chemistry: importance in process industries; Gravimetric and volumetric analysis; Acid-base, redox, precipitation, and complexometric titrations; Sampling techniques: solid, liquid, and gas samples; Errors in chemical analysis: accuracy, precision, significant figures

UNIT 2: Spectroscopic Techniques **(12 Hrs)**

UV-Visible spectroscopy: principles, instrumentation, Beer–Lambert law; Infrared (IR) spectroscopy: molecular vibrations, fingerprint region; Atomic Absorption Spectroscopy (AAS) and Flame Photometry; Introduction to NMR and Mass Spectrometry (brief principles and applications).

UNIT 3: Chromatographic Methods **(10 Hrs)**

Fundamentals of chromatography; Thin-layer chromatography (TLC), Column chromatography; Gas chromatography (GC): principles, detectors, applications; High-performance liquid chromatography (HPLC): mobile/stationary phase, detectors, data interpretation; Applications in chemical engineering: reaction monitoring, purity assessment.
.

UNIT 4: Electrochemical and Surface Analysis Techniques **(10 Hrs)**

pH measurement and potentiometry; Conductometry and electrochemical sensors; Ion-selective electrodes; Surface analysis: SEM, XRD (introductory concepts and applications in materials/energy analysis).

TEXT AND REFERENCE BOOKS

1. Skoog, D.A., Holler, F.J., and Crouch, S.R., *Principles of Instrumental Analysis*, 6th Edition, Cengage Learning, 2007.
2. Mendham, J., Denney, R.C., Barnes, J.D., and Thomas, M., *Vogel's Textbook of Quantitative Chemical Analysis*, 6th Edition, Pearson Education, 2000.
3. Willard, H.H., Merritt, L.L., Dean, J.A., and Settle, F.A., *Instrumental Methods of Analysis*, 7th Edition, CBS Publishers, 1986.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	2	-	-	-	-	-	-	-	-	-	-
CO2	2	3	2	-	2	-	-	-	-	-	-	-
CO3	2	3	3	2	2	-	-	-	-	-	-	-
CO4	2	3	2	3	-	-	-	-	-	-	-	2

CT-408	Chemical Process Optimization	L-T-P: 4-0-0	4 Credits	PCC-27

Pre-requisites: None

COURSE OBJECTIVES

1. To introduce fundamental optimization concepts and techniques for chemical process systems.
2. To develop skills in formulating and solving process optimization problems.
3. To apply optimization in design, operation, and economic evaluation of chemical plants.
4. To use computational tools for solving large-scale optimization problems.

COURSE OUTCOMES

1. Understand the principles and importance of optimization in chemical processes.
2. Formulate optimization problems for chemical engineering systems.
3. Apply appropriate optimization techniques and algorithms to solve problems.
4. Use computational tools to implement and analyze optimization models.

COURSE CONTENT

UNIT 1: Introduction to Optimization **(12 Hrs)**

Role of optimization in chemical engineering; Economic objective functions: profit, cost minimization; Basic concepts of optimization, constraints, feasible region; Classification of optimization problems; Examples from chemical process industries (e.g., reactor design, separation processes).

UNIT 2: Linear and Non-Linear Programming **(15 Hrs)**

Linear Programming (LP): formulation, standard form, graphical solution; Simplex method and duality; Sensitivity analysis; Nonlinear Programming (NLP): convexity, Kuhn–Tucker conditions; Unconstrained optimization: single-variable and multivariable methods; Constrained optimization: Lagrange multipliers.

UNIT 3: Numerical Methods and Algorithms **(15 Hrs)**

Gradient-based methods (Steepest Descent, Newton, Quasi-Newton); Penalty and Barrier methods; Sequential Quadratic Programming (SQP); Integer and Mixed-Integer Programming; Optimization using MATLAB, Python, and open-source solvers.
.

UNIT 4: Applications in Chemical Process Systems **(14 Hrs)**

Heat exchanger network synthesis (HENS) optimization; Reactor optimization: yield and selectivity improvement; Distillation column optimization; Energy integration and pinch analysis; Multi-objective optimization and trade-off analysis; Case studies in process plant optimization and scheduling.

TEXT AND REFERENCE BOOKS

1. Edgar, T.F., Himmelblau, D.M., and Lasdon, L.S., *Optimization of Chemical Processes*, 2nd Edition, McGraw-Hill, 2001.
2. Ravindran, A., Ragsdell, K.M., and Reklaitis, G.V., *Engineering Optimization: Methods and Applications*, 2nd Edition, Wiley, 2006.
3. Biegler, L.T., *Nonlinear Programming: Concepts, Algorithms, and Applications to Chemical Processes*, 1st Edition, SIAM, 2010.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)

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

CT-450	Analytical Methods in Chemical Engineering Lab	L-T-P: 0-0-3	3 Credits	PCC-28

Pre-requisites: None

COURSE OBJECTIVES

1. To provide hands-on experience with analytical instruments used in chemical and energy engineering.
2. To familiarize students with modern techniques for qualitative and quantitative analysis.
3. To develop the ability to select and operate appropriate analytical tools for real engineering problems.
4. To strengthen data analysis and interpretation skills for process control and quality assurance.

COURSE OUTCOMES

1. Explain the principles and working of analytical instruments used in engineering applications.
2. Perform experiments using spectroscopic, chromatographic, and electrochemical techniques.
3. Analyze experimental data and interpret results for engineering decisions.
4. Demonstrate safe laboratory practices and proper handling of analytical instruments.

LIST OF EXPERIMENTS

1. **pH Measurement** using pH meter and buffer calibration.
2. **Conductometric Titration** for strong acid-strong base system.
3. **UV-Visible Spectroscopy** – Calibration curve and concentration analysis.
4. **Flame Photometry** – Determination of sodium/potassium in a given sample.
5. **Colorimetric Analysis** – Determination of iron or other metal ions.
6. **Thin Layer Chromatography (TLC)** – Separation and identification of compounds.
7. **Gas Chromatography (Demonstration)** – Principle and applications.
8. **Potentiometric Titration** – Determination of chloride or other ions.
9. **Electrochemical Sensor Study** – Measurement using ion-selective electrodes.
10. **Gravimetric Analysis** – Sulfate or chloride ion determination (optional).

SAFETY AND GOOD LABORATORY PRACTICES

1. Handling of chemicals, solvents, and glassware.
2. Proper calibration and maintenance of instruments.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	2	-	-	-	-	-	-	-	-	-	-
CO2	3	3	2	-	3	-	-	-	-	-	-	-
CO3	2	3	3	2	3	-	-	-	-	-	-	2
CO4	-	-	-	-	-	3	-	-	-	-	-	-

CT-452	Major Project	L-T-P: 0-0-24	12 Credits	PW-2

Pre-requisites:

COURSE OBJECTIVE

1. To develop problem-solving, critical thinking, and project management skills.
2. To integrate knowledge and technical skills acquired during previous semesters.
3. To provide exposure to applied research, design thinking, and/or prototype development.
4. To encourage teamwork, documentation, and technical presentation abilities

COURSE OUTCOMES

After completion of the course students will be able to:

1. Identify a real-world engineering problem and define its scope and objectives
2. Apply appropriate engineering tools, techniques, and principles to solve the problem.
3. Demonstrate the ability to plan, manage time, and work collaboratively.
4. Document and present the project work effectively.

PROJECT GUIDELINES

1. Projects may be individual or team-based (2–4 students).
2. Topics should be interdisciplinary, application-oriented, or research-focused.
3. Areas can include (but are not limited to):
    a. Renewable energy systems
    b. Process simulation or modelling
    c. Pollution control and waste management
    d. Equipment design or optimization
    e. Data analysis using MATLAB/Python/Excel
    f. Fabrication of experimental setups
4. Projects must include:
    a. A clear problem statement
    b. Defined objectives and methodology
    c. Literature survey
    d. Design or modelling/experimental work
    e. Results, discussion, and conclusion
    f. Final project report and presentation

DELIVERABLES

1. Project Proposal
2. Mid-Term Review
3. Final Report **(typed)**
4. Viva-Voce / Presentation

GUIDELINES FOR FEASIBILITY REPORT AND FOR EXPERIMENTAL WORK

Content (for feasibility report)	Content (For experimental work)
Title page with well-defined title; acknowledgment, certificate, Content, List of figure/tables, notations, Abstract	
Chapter 1: Introduction (general introduction, market survey, physical and chemical properties, safety and hazards and uses)	Chapter 1: Introduction
Chapter 2: Process description and election	Chapter 2: Detailed literature review
Chapter 3: Material balance and Energy balance	Chapter 3: Methods/Experimental setup and analysis techniques Chapter 4: Results and discussions (if available)
Spiral bound, Pages- numbered, All heading/ subheading with numbers, References and Appendices.	

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)

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

This document outlines the curriculum of the Bachelor of Technology and Dual Degree (Bachelor of Technology/Master of Technology) programs offered at the University School of Chemical Technology. In the event of any difficulty in the implementation and/or interpretation of any clause of the document, the same may be brought to the notice of the Dean of the University School of Chemical Technology. The decision of the Dean of the University School of Chemical Technology shall be implemented to resolve the issue. The same shall be presented at the subsequent meeting of the Board of Studies of the University School of Chemical Technology for approval. If the decision of the Board of Studies of the University School of Chemical Technology is at variance with the decision taken earlier by the Dean of the School, the decision of the Board shall be effective from the date of the approval by the Board of Studies. In the interim (between the approval of the Dean of the School and the Board of Studies approval), the decision already taken by the Dean of the School shall remain in effect.