GURU GOBIND SINGH
INDRAPRASTHA
UNIVERSITY

B.Tech in
ENERGY 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
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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 modeling 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

ABOUT THE PROGRAMME

The **B.Tech in Energy Engineering** is a four-year undergraduate program designed to equip students with the engineering skills and scientific knowledge required to lead and innovate in today's rapidly evolving energy sector. The program provides a strong foundation in assessing and characterizing various energy resources, including conventional sources such as coal and natural gas, as well as renewable sources like solar, wind, biomass, and hydrogen. Students learn to design, develop, and optimize a wide range of energy technologies and systems, including renewable energy systems and energy storage devices. A key focus is placed on selecting the most appropriate technologies from multiple alternatives, considering performance, cost, and environmental impact.

The curriculum is structured to cover the complete energy value chain—generation and conversion, storage, transmission, and end-use. It integrates technical knowledge with an understanding of policy, environmental concerns, and emerging innovations, offering students a comprehensive and interdisciplinary learning experience. The program aims to prepare graduates to address some of society's most critical energy challenges, such as improving energy access, reducing greenhouse gas emissions, and transitioning to a low-carbon economy.
By the end of the program, students are expected to become professionals capable of designing and implementing both renewable and non-renewable energy systems. They will also be trained in energy demand-side management and sustainability strategies. Graduates will possess an understanding of global energy issues and the ability to propose both global strategy and site-specific, local solutions for sustainable development. Furthermore, they will be well-equipped to communicate and implement effective, practical energy solutions that meet consumer needs while also addressing broader concerns related to environmental impact and climate change.

Successful graduates will be able to contribute meaningfully across various roles: as innovators and entrepreneurs offering new energy solutions, as leaders in technology development and energy management, and as practicing engineers or consultants in both public and private sector organizations. The program emphasizes emerging and future-ready energy technologies, aiming to nurture professionals who can contribute to addressing pressing global energy and sustainability challenges.

Program Educational Objectives (B.Tech. – Energy Engineering)

After four years of graduation

PEO-1	**Core Competency and Technical Excellence:** Graduates will establish a strong foundation in energy systems engineering, enabling them to solve real-world problems in conventional and renewable energy sectors using modern tools, design principles, and interdisciplinary approaches.
PEO-2	**Sustainable Development and Societal Impact:** Graduates will contribute to sustainable development through innovative, environment-friendly, and energy-efficient technologies, while upholding ethical and social responsibility in their professional practice.
PEO-3	**Leadership, Lifelong Learning, and Career Growth:** Graduates will pursue successful careers in industry, research, entrepreneurship, or higher education, demonstrating leadership, effective communication, and a commitment to continuous learning in the evolving energy landscape.

Program Articulation Matrix

Mission statements / **PEO**	**PEO-1**	**PEO-2**	**PEO-3**
Providing high-quality teaching and training to students to meet the challenges in the energy 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 modeling 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	**Energy Systems Design and Optimization:** Graduates will be able to design, analyze, and optimize conventional and renewable energy systems using scientific principles and modern computational tools for efficient and sustainable energy conversion.
PSO-2	**Integration of Multidisciplinary Knowledge:** Graduates will demonstrate the ability to apply concepts from mechanical, electrical, and chemical engineering to address complex challenges in energy generation, storage, distribution, and utilization.
PSO-3	**Sustainable and Clean Energy Solutions:** Graduates will be equipped to develop and implement energy-efficient technologies and environmentally sound practices in line with global sustainability and climate change mitigation goals.
PSO-4	**Professional Competence and Innovation:** Graduates will exhibit strong professional ethics, communication skills, teamwork, and an aptitude for innovation and entrepreneurship in the evolving energy sector, with a commitment to lifelong learning.

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 Energy Engineering
2. **Bachelor of Technology (With Research)** in Energy Engineering
3. **Bachelor of Technology (Honours With Research)** in Energy 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 Energy Engineering	**B.Tech (with Research) in Energy Engineering**	**B.Tech (Honours with Research) in Energy 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)	19	15	15	15
Value-Added Courses (VAC)	8	8	8	8
Programme Core Courses (PCC)	96	**81**(= 69**+12***)	**69****	**87** (= 69** + 18****)
Programme Elective course (PEC)	12	3	3	3
Research Project (PW)	18	6	18	18
Total	**200**	**160**	**160**	**178**

@USCT students should choose the MDC subject from the other school's offered course (from USS Dwarka Campus only)
**** Basic category PCC courses offered between 1st to 7th semester, out of which PCC-6 and PCC-29 to PCC-37, these ten courses are mandatory to pass for the award of the degree.**
***** From basic category course (PCC-26, PCC-28, PCC-51, PCC-52, PCC-54& PCC-55).**
****** From honours category course (PCC-42, PCC-44, PCC-48, PCC-49, PCC-53, SEC-7 & SEC-8)**

- ***Students admitted through lateral entry admission into the second year of the B.Tech in Energy 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 Energy 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 20 credits at the honours level on top of the regular credit requirements prescribed for the B.Tech program.**

EXIT CRITERIA – B.TECH IN ENERGY 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 Energy 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 Energy 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 Energy 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	Electrical Sciences	IT-109	3
2	Mechanics of Solids	IT-106	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	Electrochemistry Lab	CT-258	2
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	Heat and Mass Transfer Lab	CT-255	2
5	Fuel and combustion lab	CT-260	2
6	Power Electronics Lab	CT-359	2
7	**Energy Storage Lab**	**CT-361**	**2**
8	**Fuel cell Technology Lab**	**CT-360**	**2**
9	Energy system modelling & simulation Lab	CT-362	2
10	Summer Training/Project##	CT-451	2
11	Solar Engineering Lab	CT-455	2
		Total	**19**

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 * (*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		Heat and Mass Transfer	CT-213	3
4		Fluid Mechanics and Fluid Machineries	CT-215	3
5		Engineering Thermodynamics	CT-209	4
6		Reaction Engineering	CT-219	3
7		Fundamental of Energy Engineering	CT-217	2
8		Energy Resources and Utilization	CT-212	3
9		Basics of Renewable Energy Technology	CT-214	3
10		Instrumentation and Control for Energy Systems	CT-216	3
11		Electrochemistry	CT-218	3
12		Biomass and Bio-fuel Technology	CT-220	3
13		Hydrogen Technology	CT-222	3
14		Nuclear Power Engineering	CT-319	3
15		Materials for Energy Applications	CT-321	3
16		Power Electronics	CT-323	3
17		Energy Audit and Management	CT-318	3
18		Wind, Hydro and Ocean Technology	CT-322	3
19		Energy system modelling & simulation	CT-324	3
20		Energy conservation, recovery and management	CT-326	3
21		Solar Engineering	CT-427	3
22		Power Generation, Transmission and Utilization	CT-410	4
23		Fundamentals of Electrical Vehicle Technology	CT-412	4
24		Analytical Methods in Engineering	CT-406	3
25		Waste to Bio-energy	CT-416	3
26		Analytical Methods in Engineering Lab	CT-450	2
27		Waste to Bio-energy Lab	CT-454	2
			Total (Basic)	**80**
28	**Honours Courses**	**Energy Storage Systems**	**CT-325**	**3**
29		**Fuel cell Technology**	**CT-320**	**3**
30		**Photovoltaic Conversion Technology**	**CT-423**	**3**
31		**Energy Economics, Policy and Regulation**	**CT-425**	**3**
32		**Advanced Power Electronics for Renewable Energy Systems**	**CT-414**	**4**
			Total (Honours)	**16**
			Total (Basic + Honours)	**96**

Programme Elective Courses (PEC):

Sl.	Group	Course Name	Course Code	Credit
1	Elective-I	Electrical Machines	CT-327	3
2		Clean Coal and Gas Technology	CT-329	
3	Elective-II	Advanced Bio-fuel Technology	CT-328	3
4		Waste to Energy	CT-330	
5	Elective-III	Nanotechnology for Energy Systems	CT-429	3
6		Environmental Impact Assessment	CT-417	
7	Elective-IV	Introduction to Computational Fluid Dynamics	CT-415	3
8		Waste Heat Recovery	CT-431	
			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	2	4	4	4		19
VAC	2	2	2	2					8
PCC	2	3	15	18	12	15	9	22	96
PEC					3	3	6		12
PW							6	12	18
Total	**24**	**24**	**24**	**24**	**21**	**24**	**25**	**34**	**200**

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/ 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-109	Electrical Sciences	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/ 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-106	Mechanics of Solids	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		BS-162	Engineering Physics Lab - II	BSC-9	B	0 – 0 – 2	1
11		IT-152	Engineering Graphics	SEC-3	B	0 – 0 – 2	1
		MOOCs-2	**Engineering Drawing and Computer Graphics (*MOOCs/Swayam#*)**				
			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/ Honours	Contact L – T - P	Credits
1		CT-201	Numerical Methods for Engineers	AEC-3	B	2 – 0 – 0	2
2		CT-209	Engineering Thermodynamics	PCC-6	B	4– 0 – 0	4
3		CT-213	Heat and Mass Transfer	PCC-29	B	3 – 0 – 0	3
4		CT-215	Fluid Mechanics and Fluid Machineries	PCC-30	B	3– 0 – 0	3
5		CT-217	Fundamental of Energy Engineering	PCC-31	B	2 – 0 – 0	2
6		CT-219	Reaction Engineering	PCC-32	B	3 – 0 – 0	3
7			**Multidisciplinary course (To be opted among the offered electives from other discipline)**	**MDC-3$**	**B**	**3 – 0 – 0**	**3**
8		CT-253	Seminar-I	VAC-3*	B	0 – 0 – 3	2
9		CT-255	Heat and Mass Transfer Lab	SEC-4	B	0 – 0 – 3	2
			Total			**26**	**24**

FOURTH SEMESTER

Sl.	Paper ID	Course Code	Course Name	Category Code	Type: Basic/ Honours	Contact L – T - P	Credits
1		CT-212	Energy Resources and Utilization	PCC-33	B	3 – 0 – 0	3
2		CT-214	Basics of Renewable Energy Technology	PCC-34	B	3– 0 – 0	3
3		CT-216	Instrumentation and Control for Energy Systems	PCC-35	B	3 – 0 – 0	3
4		CT-218	Electrochemistry	PCC-36	B	3 – 0 – 0	3
5		CT-220	Biomass and Biofuel Technology	PCC-37	B	3 – 0 – 0	3
6		CT-222	Hydrogen Technology	PCC-38	B	3 – 0 – 0	3
7		CT-256	NSS/NCC/Cultural Clubs/ Technical Society/ Technical Club*	VAC-4*	B	0 – 0 – 0	2
8		CT-258	Electrochemistry Lab	AEC-4	B	0 – 0 – 3	2
9		CT-260	Fuel and combustion lab	SEC-5	B	0 – 0 – 3	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/ Honours	Contact L – T - P	Credits
1		CT-319	Nuclear Power Engineering	PCC-39	B	3 – 0 – 0	3
2		CT-321	Materials for Energy Applications	PCC-40	B	3 – 0 – 0	3
3		CT-323	Power Electronics	PCC-41	B	3 – 0 – 0	3
4		**CT-325**	**Energy Storage Systems**	**PCC-42**	**H**	**3 – 0 – 0**	**3**
5			**Elective – I**	**PEC-5**		**3 – 0 – 0**	**3**
		MOOCs -3	**Equivalent course from *MOOCs/Swayam#***				
6		CT-357	Summer Training / Summer Project ##	AEC-5	B	0 – 0 – 0	2
7		CT-359	Power Electronics Lab	SEC-6	B	0 – 0 – 4	2
8		CT-361	**Energy Storage Lab**	**SEC-7**	**H**	**0 – 0 – 4**	**2**
			Total			**23**	**21**

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-5) List:

Sl.	Paper ID	Course Code	Course Name
1		CT-327	Electrical Machines
2		CT-329	Clean Coal and Gas Technology

SIXTH SEMESTER

Sl.	Paper ID	Course Code	Course Name	Category Code	Type: Basic/ Honours	Contact L – T - P	Credits
1		CT-318	Energy Audit and Management	PCC-43	B	3 – 0 – 0	3
2		**CT-320**	**Fuel cell Technology**	**PCC-44**	**H**	**3 – 0 – 0**	**3**
3		CT-322	Wind, Hydro and Ocean Technology	PCC-45	B	3 – 0 – 0	3
4		CT-324	Energy system modelling & simulation	PCC-46	B	3 – 0 – 0	3
5		CT-326	Energy conservation, recovery and management	PCC-47	B	3 – 0 – 0	3
6			**Elective - II**	**PEC-6**	**B**	**3 – 0 – 0**	**3**
		MOOCs -4	**Equivalent course from *MOOCs/Swayam#***				
7		CT-356	Seminar-II	AEC-6	B	0 – 0 – 3	2
8		**CT-360**	**Fuel cell Technology Lab**	**SEC-8**	**H**	**0 – 0 – 4**	**2**
9		CT-362	Energy system modelling & simulation Lab	SEC-9	B	0 – 0 – 3	2
			Total			**28**	**24**

Elective-II (PEC-6) List:

Sl.	Paper ID	Course Code	Course Name
1		CT-328	Advanced Biofuel Technology
2		CT-330	Waste to Energy

Fourth Year

SEVENTH SEMESTER

Sl.	Paper ID	Course Code	Course Name	Category Code	Type: Basic/ Honours	Contact L – T - P	Credits
1		CT-423	Photovoltaic Conversion Technology	PCC-48	H	3 – 0 – 0	3
2		CT-425	Energy Economics, Policy and Regulation	PCC-49	H	3 – 0 – 0	3
3		CT-427	Solar Engineering	PCC-50	B	3– 0 – 0	3
4			Elective - III	PEC-7	B	3 – 0 – 0	3
		MOOCs -5	Equivalent course from *MOOCs/Swayam#*				
5			Elective – IV	PEC-8	B	3 – 0 – 0	3
		MOOCs -6	Equivalent course from *MOOCs/Swayam#*				
6		CT-451	Summer Training/Project ##	SEC-10	B	0 – 0 – 0	2
7		CT-453	Minor Project	PW-1	B	0 – 0 – 12	6
8		CT-455	Solar Engineering Lab	SEC-11	B	0 – 0 – 3	2
			Total			**30**	**25**

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-7) List:

Sl.	Paper ID	Course Code	Course Name
1		CT-429	Nanotechnology for Energy Systems
2		CT-417	Environmental Impact Assessment

Elective-IV (PEC-8) List:

Sl.	Course Code	Paper Code	Paper
1		CT-415	Introduction to Computational Fluid Dynamics
2		CT-431	Waste Heat Recovery

EIGHTH SEMESTER

Sl.	Paper ID	Course Code	Course Name	Category Code	Type: Basic/ Honours	Contact L – T - P	Credits
1		CT-406	Analytical Methods in Engineering	PCC-26	B	3 – 0 – 0	3
2		CT-410	Power Generation, Transmission and Utilization	PCC-51	B	4– 0 – 0	4
3		CT-412	Fundamentals of Electrical Vehicle Technology	PCC-52	B	4– 0 – 0	4
4		CT-414	Advanced Power Electronics for Renewable Energy Systems	PCC-53	H	4 – 0 – 0	4
5		CT-416	Waste to Bio-energy	PCC-54	B	3 – 0 – 0	3
6		CT-450	Analytical Methods in Engineering Lab	PCC-28	B	0 – 0 – 3	2
7		CT-452	Major Project	PW-2	B	0 – 0 – 24	12
8		CT-454	Waste to Bio-energy Lab	PCC-55	B	0 – 0 – 3	2
			Total			**48**	**34**

- **#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 Energy Engineering or B.Tech (Honours with Research) in Chemical Engineering degrees. ***Such students shall be awarded the B.Tech in Energy 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 fulfill 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-109	Electrical Sciences	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 and 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.
3. Atkins, P. W., *Physical Chemistry*, 9th Edition, Oxford University Press, 2009.
4. Puri, B. R., Sharma, L. R., and Pathania, M. S., *Principles of Physical Chemistry*, 47th Edition, Vishal Publishing Co., 2017.
5. Holmberg, K., Jönsson, B., Kronberg, B., and Lindman, B., *Surfactants and Polymers in Aqueous Solution*, 2nd Edition, John Wiley & Sons, 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	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-109	Electrical Sciences	L-T-P: 3-0-0	3 Credits	ESC-1

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

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

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: None

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*, 8thEdition, McGraw Hill, 2019.
2. Gottfried, B., *Programming with C*, 3rdEdition, 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-106	Mechanics of Solids	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		BS-162	Engineering Physics Lab - II	BSC-9	B	0 – 0 – 2	1
11		IT-152	Engineering Graphics	SEC-3	B	0 – 0 – 2	1
		MOOCs-2	**Engineering Drawing and Computer Graphics (*MOOCs/Swayam#*)**				
			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.**

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*, 10th Edition, Oxford University Press, 2014.
2. Glasstone, S., *Thermodynamics for Chemists*, 1st Edition, Affiliated East-West Press, 1946.
3. Glasstone, S., *An Introduction to Electrochemistry*, 1st Edition, Read Books, 1942.
4. Rakshit, P.C., *Physical Chemistry*, 7th Edition, Sarat Book Distributor, 2016.
5. Barrow, G.M., *Physical Chemistry*, 5th Edition, 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*, 10thEdition, 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-106	Mechanics of Solids	L-T-P: 3-0-0	3 Credits	ESC-2

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*, Umesh Publications, 2010.
2. Kumar, K. L., *Engineering Mechanics*, Tata McGraw-Hill, 2008.
3. Timoshenko, S., Young, D. H., and Rao, J. V., *Engineering Mechanics*, Tata McGraw-Hill, 2007.
4. Shames, I. H., *Engineering Mechanics: Statics and Dynamics*, PHI Learning, 2006.
5. Bhattacharya, B., *Engineering Mechanics*, Oxford Higher Education, 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	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

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., 12thEdition, 2015.
3. Khurmi, R.S. and Gupta, J.K., *Workshop Technology (Manufacturing Processes)*, S. Chand Publications, 5thEdition, 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-209	Engineering Thermodynamics	PCC-6	B	4– 0 – 0	4
3		CT-213	Heat and Mass Transfer	PCC-29	B	3 – 0 – 0	3
4		CT-215	Fluid Mechanics and Fluid Machineries	PCC-30	B	3– 0 – 0	3
5		CT-217	Fundamental of Energy Engineering	PCC-31	B	2 – 0 – 0	2
6		CT-219	Reaction Engineering	PCC-32	B	3 – 0 – 0	3
7			**Multidisciplinary course (To be opted among the offered electives from other discipline)**	**MDC-3$**	**B**	**3 – 0 – 0**	**3**
8		CT-253	Seminar-I	VAC-3*	B	0 – 0 – 3	2
9		CT-255	Heat and Mass Transfer Lab	SEC-4	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-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-213	Heat and Mass Transfer	L-T-P: 3-0-0	3 Credits	PCC-29

Pre-requisites: None

COURSE OBJECTIVES

1. To introduce the fundamentals of conduction, convection, radiation, and phase-change heat transfer.
2. To develop analytical and problem-solving skills to evaluate energy transfer mechanisms in systems.
3. To impart knowledge of mass transfer principles and their relevance to thermal-energy applications.
4. To familiarize students with industrial and renewable energy systems involving heat and mass exchange.

COURSE OUTCOMES

After completion of the course students will be able to:

1. Understand and analyze heat transfer mechanisms—conduction, convection, and radiation—in steady and transient regimes.
2. Apply theoretical and empirical correlations to solve heat transfer problems in energy systems.
3. Analyze mass transfer processes and evaluate diffusional phenomena in fluids and solids.
4. Solve practical problems involving combined heat and mass transfer relevant to energy and environmental applications.

COURSE CONTENT

UNIT 1: Conduction Heat Transfer **(10 Hrs)**

Basic concepts: modes of heat transfer, Fourier's law, One-dimensional steady-state conduction: plane wall, cylinder, sphere, Thermal resistance concept and composite walls, Variable thermal conductivity and internal heat generation, Heat transfer in extended surfaces (fins), Transient conduction: lumped system analysis and Biot number, Heisler charts and semi-infinite solids.

UNIT 2: Convective Heat Transfer **(12 Hrs)**

Fundamentals of convection: boundary layer theory, Forced convection: external (flat plate, cylinders) and internal flows (pipes), Empirical correlations for Nusselt number estimation, Natural convection: governing equations and correlations for vertical plates and cylinders, Combined convection, Heat exchangers: classification, LMTD and effectiveness-NTU methods, Applications in solar collectors and power plants.

UNIT 3: Thermal Radiation **(9 Hrs)**

Basic concepts: black body radiation, Stefan-Boltzmann law, Planck's law, Radiation properties of surfaces: emissivity, absorptivity, reflectivity, Radiation heat exchange between surfaces, View factors and enclosure analysis, Radiation shielding and gas radiation in combustion chambers, Applications in thermal insulation and radiative cooling.

UNIT 4: Mass Transfer Principles **(9 Hrs)**

Introduction to molecular diffusion in gases and liquids, Fick's laws of diffusion and unsteady diffusion, Mass transfer coefficients and analogy with heat transfer (Reynolds, Chilton-Colburn analogies), Convective mass transfer in laminar and turbulent flows, Applications: drying, humidification, membrane separation, Combined heat and mass transfer: cooling towers, evaporators, desiccant systems

TEXT AND REFERENCES BOOKS

1. Cengel, Y. A., and Ghajar, A. J., *Heat and Mass Transfer – Fundamentals and Applications*, 6th Edition, McGraw Hill, 2020.
2. Holman, J. P., *Heat Transfer*, 10th Edition, McGraw Hill, 2010.
3. Incropera, F. P., and DeWitt, D. P., *Fundamentals of Heat and Mass Transfer*, 7th Edition, Wiley, 2011.
4. Kreith, F., and Bohn, M. S., *Principles of Heat Transfer*, 7th Edition, Cengage Learning, 2001.
5. Nag, P. K., *Heat and Mass Transfer*, 3rd Edition, McGraw Hill Education, 2011.
6. Sachdeva, R. C., *Fundamentals of Engineering Heat and Mass Transfer*, 5th Edition, New Age International, 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	2	2	1	-	-	-	-	-	-	2
CO2	3	3	3	2	2	-	2	-	-	-	-	2
CO3	3	2	2	2	2	-	3	-	-	-	-	2
CO4	3	3	2	3	2	2	3	-	-	-	-	3

CT-215	Fluid Mechanics and Fluid Machineries	L-T-P: 3-0-0	3 Credits	PCC-30

Pre-requisites: None

COURSE OBJECTIVES

1. To introduce the fundamental principles of fluid statics, kinematics, and dynamics.
2. To enable students to apply conservation laws for solving fluid flow problems in energy systems.
3. To analyze the performance of hydraulic and energy conversion devices like pumps and turbines.
4. To prepare students for designing and analyzing fluid machinery used in renewable and conventional power systems.

COURSE OUTCOMES

After completion of the course students will be able to:

1. Understand the fundamental properties and governing equations of fluid flow
2. Analyze fluid flow behavior using Bernoulli's, continuity, and momentum equations.
3. Evaluate the performance characteristics of turbines, pumps, and other fluid machinery
4. Apply fluid mechanics principles in the context of energy engineering systems.

COURSE CONTENT

UNIT 1: Fluid Properties and Fluid Statics (10 Hrs)

Definition and classification of fluids**;** Fluid properties: density, viscosity, surface tension, compressibility**;** Pascal's law and hydrostatic pressure distribution**;** Manometers and pressure measuring devices**;** Forces on submerged surfaces – horizontal, vertical, inclined surfaces**;** Buoyancy and stability of floating bodies**;** Applications in pressure vessels, hydroelectric dams, storage tanks.

UNIT 2: Fluid Kinematics and Dynamics (12 Hrs)

Description of fluid motion: Lagrangian and Eulerian**;** Streamline, pathline, streakline; stream function and velocity potential**;** Continuity equation (1D and differential form)**;** Bernoulli's equation and its applications: venturimeter, orifice meter, pitot tube**;** Linear and angular momentum principles; flow through nozzles**;** Navier–Stokes equation (introduction); dimensional analysis and similitude**;** Flow measurement techniques in wind tunnels and pipelines.

UNIT 3: Laminar and Turbulent Flow in Pipes (9 Hrs)

Reynolds experiment and classification of flow; Laminar flow in circular pipes: Hagen–Poiseuille equation; Darcy-Weisbach equation and major/minor losses in pipes; Moody diagram and friction factor estimation; Pipe network analysis and energy losses; Boundary layer concept, boundary layer thickness, separation; Applications in HVAC systems, water distribution, geothermal flow.

UNIT 4: Fluid Machineries (9 Hrs)

Classification and working principles of fluid machines; Impact of jet on plates and vanes; Turbines: Impulse vs. Reaction Turbines; Pelton, Francis, and Kaplan turbines – working, velocity triangles, efficiency; Pumps: Reciprocating and centrifugal pumps – construction, operation, characteristics, Priming, cavitation, specific speed, net positive suction head (NPSH); Performance curves and model testing; Applications in hydropower plants, cooling systems, irrigation, and biomass conversion.

TEXT AND REFERENCES BOOKS

1. Bansal, R. K., *A Textbook of Fluid Mechanics and Hydraulic Machines*, Laxmi Publications, 2017.
2. Cengel, Y. A., and Cimbala, J. M., *Fluid Mechanics: Fundamentals and Applications*, 4th Edition, McGraw-Hill, 2017.
3. Modi, P. N., and Seth, S. M., *Hydraulics and Fluid Mechanics*, 22nd Edition, Standard Book House, 2019.
4. Som, S. K., and Biswas, G., *Introduction to Fluid Mechanics and Fluid Machines*, 3rd Edition, McGraw-Hill, 2011.
5. Streeter, V. L., Wylie, E. B., and Bedford, K. W., *Fluid Mechanics*, 9th Edition, McGraw-Hill, 1998.
6. White, F. M., *Fluid Mechanics*, 8th Edition, McGraw-Hill, 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	3	2	-	2	-	-	-	-	2
CO3	3	3	3	2	2	-	2	-	-	-	-	2
CO4	3	3	3	3	3	2	3	-	-	-	2	3

CT-217	Fundamental of Energy Engineering	L-T-P: 2-0-0	2 Credits	PCC-31

Pre-requisites: None

COURSE OBJECTIVES

1. To introduce the types, sources, and consumption patterns of energy.
2. To provide fundamental knowledge of conventional and renewable energy technologies.
3. To impart analytical understanding of energy flow, utilities, and system efficiency.
4. To sensitize students to environmental impacts and sustainable energy practices.

COURSE OUTCOMES

After completion of the course students will be able to:

1. Understand and classify various energy resources and analyze their consumption patterns across sectors.
2. Explain working principles of conventional power generation systems and their limitations.
3. Describe various renewable and unconventional energy technologies and evaluate their sustainability.
4. Apply basic concepts of energy flow, efficiency, and sustainability tools (e.g., Sankey diagram, LCA).

COURSE CONTENT

UNIT 1: Energy Resources and Sectoral Energy Use (6 Hrs)

Classification of energy resources:Primary vs. secondary, Renewable vs. non-renewable, Commercial and non-commercial. **Global and Indian energy scenario**:Energy reserves, Per capita energy consumption, Energy security and challenges. **Energy consumption patterns**:Sector-wise (industrial, residential, commercial, agricultural, transportation), Urban vs. rural energy use, Growth trends and policy implications. **Basics of energy auditing**:Need and scope, Key metrics: TOE, kWh, GJ, etc., Introduction to benchmarking.

UNIT 2: Conventional Power Generation Technologies (8 Hrs)

Steam Turbine Power Plant:Rankine cycle with regenerative and reheat cycles, Boiler, condenser, superheater, and economizer, Efficiency calculations and heat rate, Environmental issues (emissions, water use). **Gas Turbine Power Plant**:Brayton cycle, intercooling, regeneration, Combined cycle plants (CCGT). **Internal Combustion Engines (ICE)**:Otto and Diesel cycles, SI and CI engine characteristics, Fuel types and emissions. **Fuel Cells**:Principle and types (PEMFC, SOFC, etc.), Thermodynamics and efficiency, Applications and future potential. **Limitations and environmental effects**:CO_2 emissions, pollutants, and waste heat, Water usage and thermal pollution.

UNIT 3: Renewable and Unconventional Energy Technologies (8 Hrs)

Solar Energy: Solar radiation basics, Photovoltaic systems: types of cells (mono/poly crystalline, thin film), efficiency factors, Solar thermal collectors: flat plate, evacuated tube, solar concentrators. **Wind Energy**: Wind energy conversion principles, Types of turbines (HAWT, VAWT), Betz limit and power curve, Site selection and environmental constraints. **Hydropower**: Classification (run-of-river, pumped storage, etc.), Head and flow rate concepts, Turbine types (Pelton, Francis, Kaplan). **Bioenergy**: Biomass combustion, gasification, pyrolysis, Biogas plants (floating dome, fixed dome), Biofuels: ethanol, biodiesel. **Nuclear Energy**: fission/fusion basics, types of reactors, safety and waste. T**idal and Wave Energy**: working principles, technologies under development.

UNIT 4: Energy Efficiency, Flow Analysis, and Sustainability (6 Hrs)

Energy flow diagrams and Sankey diagrams; Thermal and electrical utilities; efficiency improvement strategies; Life Cycle Assessment (LCA), carbon footprint, and environmental impact of energy systems; Demand and supply analysis, smart grid concepts, sustainable energy solutions for built environment; Energy conservation building code (ECBC).

TEXT AND REFERENCES BOOKS

1. Hodge, B. K., *Alternative Energy Systems and Applications*, 2nd Edition, Wiley, 2017.
2. Rai, G. D., *Non-Conventional Energy Sources*, 5th Edition, Khanna Publishers, 2011.
3. Sukhatme, S. P., and Nayak, J. K., *Solar Energy: Principles of Thermal Collection and Storage*, 3rd Edition, Tata McGraw-Hill, 2008.
4. Goswami, D. Y., and Kreith, F., *Energy Conversion*, CRC Press, 2007.
5. Bureau of Energy Efficiency (BEE), *Energy Manager & Auditor Guidebooks*, Government of India, Latest Edition (available at www.beeindia.gov.in).
6. *IPCC Reports*, *MNRE*, and *IEA websites* – Consult latest data and policy briefs at www.ipcc.ch, www.mnre.gov.in, and www.iea.org.

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

CT-219	Reaction Engineering	L-T-P: 3-0-0	3 Credits	PCC-32

Pre-requisites: BSC-119 & BSC-116

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 **(10 Hrs)**

Reaction kinetics: 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 **(12 Hrs)**

Reactors: 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);

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

UNIT 3 **(12 Hrs)**

Designing of single and parallel reactions: 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 **(8 Hrs)**

Flow behavior of reactors: 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-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

CT-255	Heat and Mass Transfer Lab	L-T-P: 0-0-3	2 Credits	SEC-4

Pre-requisites: None

COURSE OBJECTIVES

1. To provide practical understanding of heat and mass transfer concepts through experiments.
2. To familiarize students with industrial equipment such as heat exchangers, evaporators, and dryers.
3. To enable students to evaluate heat/mass transfer coefficients and performance parameters experimentally.
4. To enhance analytical and interpretation skills for real-time engineering applications

COURSE OUTCOMES

After completion of the course students will be able to:

1. Understand the working and performance of heat and mass transfer equipment.
2. Conduct experiments to determine heat and mass transfer coefficients.
3. Analyze experimental data using theoretical correlations and performance equations.
4. Apply concepts of heat and mass transfer in design and operation of process equipment.

LIST OF EXPERIMENTS

1. **Heat transfer in Double Pipe Heat Exchanger** – Determination of LMTD and U-value.
2. **Heat transfer in Shell & Tube Heat Exchanger** – Efficiency and overall coefficient.
3. **Performance of Plate Heat Exchanger** – Effect of flow arrangement on heat transfer.
4. **Natural Convection Apparatus** – Determination of heat transfer coefficient.
5. **Forced Convection Apparatus** – Correlation between Nusselt, Reynolds, and Prandtl numbers.
6. **Stefan-Boltzmann Apparatus** – Verification of radiation law.
7. **Emissivity Measurement Apparatus**.
8. **Water Evaporation from a Surface (Open Pan Dryer)** – Estimation of drying rate and constant rate period.
9. **Solid in Liquid Diffusion Study** – Estimation of diffusion coefficient.
10. **Mass Transfer in Packed Column** – Determination of mass transfer coefficient.

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	2	2	-	-	-	-	-	-	-
CO3	2	3	3	3	3	-	-	-	-	-	-	2
CO4	2	2	3	2	3	-	-	-	-	-	-	2

FOURTH SEMESTER

Sl.	Paper ID	Course Code	Course Name	Category Code	Basic/ Honours	Contact L – T - P	Credits
1		CT-212	Energy Resources and Utilization	PCC-33	B	3 – 0 – 0	3
2		CT-214	Basics of Renewable Energy Technology	PCC-34	B	3– 0 – 0	3
3		CT-216	Instrumentation and Control for Energy Systems	PCC-35	B	3 – 0 – 0	3
4		CT-218	Electrochemistry	PCC-36	B	3 – 0 – 0	3
5		CT-220	Biomass and Biofuel Technology	PCC-37	B	3 – 0 – 0	3
6		CT-222	Hydrogen Technology	PCC-38	B	3 – 0 – 0	3
7		CT-256	NSS/NCC/Cultural Clubs/ Technical Society/ Technical Club*	VAC-4*	B	0 – 0 – 0	2
8		CT-258	Electrochemistry Lab	AEC-4	B	0 – 0 – 3	2
9		CT-260	Fuel and combustion lab	SEC-5	B	0 – 0 – 3	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.**

CT-212	Energy Resources and Utilization	L-T-P: 3-0-0	3 Credits	PCC-33

Pre-requisites: None

COURSE OBJECTIVES
1. To classify and analyze various conventional and non-conventional energy resources and their potential.
2. To study fuel properties and characterization techniques essential for energy conversion.
3. To understand thermochemical processes such as combustion and gasification.
4. To explore practical utilization of fuels in various systems and assess environmental implications.

COURSE OUTCOMES
After completion of the course students will be able to:
1. Identify and compare conventional and non-conventional energy resources.
2. Characterize fuels using standard techniques and interpret their impact on energy conversion.
3. Explain combustion and gasification processes with reference to thermodynamics and chemical kinetics.
4. Analyze fuel utilization in practical systems and evaluate environmental effects of various energy technologies.

COURSE CONTENT
UNIT 1: Overview of Energy Resources and Potential (9 Hrs)

Classification of energy resources: Conventional: coal, petroleum, natural gas, Non-conventional: solar, wind, biomass, geothermal, tidal, OTEC, etc. Global and Indian scenario: Availability and reserves of coal, oil, natural gas, Renewable resource mapping: solar irradiation, wind atlas, biomass potential.

UNIT 2: Fuel Properties and Characterization Techniques (11 Hrs)

Coal classification and types: peat, lignite, bituminous, anthracite. Petroleum and natural gas composition. Solid and liquid fuel characterization: Ultimate analysis: C, H, N, S, O, Proximate analysis: moisture, ash, volatile matter, fixed carbon, Calorific value (GCV, NCV): Bomb calorimeter, Ash fusion temperature, HGI, VM%, Gaseous fuels: calorific value, Wobbe index, specific gravity, Environmental indices: sulfur content, ash disposal parameters.

UNIT 3: Fuel Conversion Technologies – Combustion and Gasification (11 Hrs)

Combustion fundamentals: Stoichiometry, excess air, flue gas composition, Adiabatic flame temperature, Emission products and combustion efficiency. Types of combustion: Fixed bed, fluidized bed, suspension combustion, Combustion in IC engines, furnaces, boilers. Gasification fundamentals: Types: updraft, downdraft, fluidized bed, entrained flow, Gasifier design basics, Producer gas, syngas: composition and heating value. Comparison of combustion vs. gasification. Gas cleaning and conditioning (cyclones, filters, scrubbers).

UNIT 4: Fuel Utilization and Environmental Considerations (11 Hrs)

Fuel utilization systems: Steam turbines (Rankine cycle with solid/liquid fuels), Gas turbines (Brayton cycle with syngas, natural gas), Internal combustion engines (CI & SI modes). Nuclear energy: Types of nuclear fuels, Fuel cycle overview, Basics of fission reaction and reactor types, Environmental impact of fuel usage: Emissions: SOx, NOx, CO_2, particulate matter, Thermal pollution and water use, Ash handling and disposal, Lifecycle impacts: mining, processing, and conversion.

TEXT AND REFERENCES BOOKS

1. Rai, G. D., *Non-Conventional Energy Sources*, 5th Edition, Khanna Publishers, 2011.
2. Sarkar, S., *Thermal Engineering*, 18th Edition, Tata McGraw-Hill, 2004.
3. Sharma, B. K., *Engineering Chemistry*, 12th Edition, Krishna Prakashan Media, 2003.
4. Kuo, Kenneth K., *Principles of Combustion*, 2nd Edition, Wiley, 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	2	-	-	1	2	2	-	-	-	1	-
CO2	3	2	2	-	2	1	2	-	-	-	2	-
CO3	3	2	3	2	2	2	3	-	-	-	2	2
CO4	3	2	3	3	3	2	3	-	-	-	2	2

CT-214	Basics of Renewable Energy Technology	L-T-P: 3-0-0	3 Credits	PCC-34

Pre-requisites: BS-119 & BS-116

COURSE OBJECTIVES

1. To introduce the fundamental principles of renewable energy resources and their technologies.
2. To understand the technical and environmental aspects of solar, wind, biomass, and other renewable systems.
3. To explore the integration of renewable technologies for sustainable development.
4. To provide insight into energy policy, economics, and environmental impact.

COURSE OUTCOMES

1. Understand the potential, scope, and limitations of various renewable energy sources.
2. Explain the working principles of solar, wind, biomass, and hydro energy systems.
3. Analyze and compare technologies for renewable energy conversion and utilization.
4. Apply renewable energy concepts to real-world sustainability challenges.

COURSE CONTENT

UNIT 1: Introduction to Renewable Energy Systems (9 Hrs)

Global and national energy scenario; Limitations of fossil fuels, climate change, and energy security; Classification and potential of renewable energy sources; Basic thermodynamic and energy conversion concepts; Comparison of renewable and non-renewable energy; Energy efficiency and sustainability indicators.

UNIT 2: Solar Energy Technologies (12 Hrs)

Solar radiation: extra-terrestrial, terrestrial, insolation measurement; Solar thermal systems: flat plate and concentrating collectors, solar water heating; Basics of solar PV: working principle, types of cells (mono/poly/thin film); Components of PV systems: modules, inverters, MPPT, batteries; Solar applications: home lighting, pumping, grid-connected systems; Performance and efficiency considerations.

UNIT 3: Wind, Biomass and Small Hydro Energy (12 Hrs)

Wind energy: wind speed distribution, types of wind turbines, tip speed ratio, power coefficient; Wind turbine components, site selection, basics of wind farm design; Biomass resources and conversion: biogas, biomass combustion, gasification; Basics of anaerobic digestion and biofuels (ethanol, biodiesel); Small hydro systems: types (run-of-river, pumped storage), components and site criteria.

UNIT 4: Emerging Technologies and Integration Aspects (9 Hrs)

Geothermal, ocean (tidal, wave), and hydrogen energy basics; Energy storage: batteries, pumped hydro, thermal storage; Smart grid and hybrid renewable systems; Renewable energy policies in India (MNRE, National Solar Mission); Introduction to lifecycle analysis, environmental and economic impact; Case studies of integrated and off-grid systems.

TEXT AND REFERENCES BOOKS

1. Twidell, J., and Weir, T., *Renewable Energy Resources*, 4th Edition, Taylor and Francis, 2021.
2. Sukhatme, S. P., and Nayak, J. K., *Solar Energy: Principles of Thermal Collection and Storage*, 4th Edition, McGraw Hill, 2017.
3. Kothari, D. P., Singal, K. C., and Ranjan, R., *Renewable Energy Sources and Emerging Technologies*, 2nd Edition, PHI Learning, 2011.
4. Solanki, Chetan Singh, *Solar Photovoltaics: Fundamentals, Technologies and Applications*, 3rd Edition, PHI Learning, 2015.
5. Rai, G. D., *Non-Conventional Energy Sources*, 5th Edition, Khanna Publishers, 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	1	1	2	3	2	-	-	-	2
CO2	2	3	2	2	2	1	2	1	-	-	-	1
CO3	2	2	3	2	2	2	2	1	-	1	-	2
CO4	2	2	3	2	3	2	3	2	1	1	1	3

CT-216	Instrumentation and Control for Energy Systems	L-T-P: 3-0-0	3 Credits	PCC-35

Pre-requisites: None

COURSE OBJECTIVES

1. To introduce principles of measurement and instrumentation relevant to energy systems.
2. To familiarize students with sensors, transducers, and signal conditioning for energy applications.
3. To provide knowledge of process control principles and their application in energy systems.
4. To develop the ability to design and analyze control systems for energy processes.

COURSE OUTCOMES

1. Explain the working principles of sensors, transducers, and instrumentation used in energy systems.
2. Select appropriate instrumentation for measurement and monitoring of energy processes.
3. Apply fundamental control principles to energy systems for stable and efficient operation.
4. Design and analyze control systems for boilers, heat exchangers, and renewable energy setups.

COURSE CONTENT

UNIT 1: Basics of Instrumentation (10 Hrs)

Principles of measurement and instrumentation; Static and dynamic characteristics of instruments; Error analysis: accuracy, precision, calibration; Sensors and transducers: temperature (RTD, thermocouples), pressure, flow, level, and torque sensors; Signal conditioning systems: amplifiers, filters, A/D, D/A converters.

UNIT 2: Instrumentation for Energy Systems (12 Hrs)

Measurement of solar radiation, wind speed, biomass properties, and geothermal parameters; Temperature measurement in boilers, heat exchangers, and reactors; Pressure and flow measurement in energy systems (steam, gas, liquid); Measurement of electrical quantities: voltage, current, power, and energy meters; Advanced sensors: optical fiber sensors, smart sensors for energy applications.

UNIT 3: Control System Fundamentals (10 Hrs)

Introduction to process control; Open-loop and closed-loop control systems; Control elements: controllers (P, PI, PID), control valves, actuators; Block diagram representation and transfer function models; Stability analysis: Routh-Hurwitz criterion.

UNIT 4: Control of Energy Systems (10 Hrs)

Control of boilers and heat exchangers; Control strategies for solar thermal systems and wind turbines; Control of biomass gasifiers and fuel cells; SCADA and DCS for energy systems monitoring; Introduction to automation and digital control for smart grids and renewable energy integration.

TEXT AND REFERENCES BOOKS

1. Johnson, Curtis D., *Process Control Instrumentation Technology*, 8th Edition, Pearson, 2013.
2. Lipták, B. G., *Instrumentation Engineers' Handbook*, 4th Edition, CRC Press, 2003.
3. Krishnaswamy, K., and Vijayachitra, S., *Industrial Instrumentation and Control*, 1st Edition, New Age International, 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	2	-	-	-	-	-	-	-	-	-	-
CO2	3	3	2		2	-	-	-	-	-	-	-
CO3	2	3	3	3	3	-	-	-	-	-	-	2
CO4	2	2	3	3	3	-	-	-	-	-	-	2

CT-218	Electrochemistry	L-T-P: 3-0-0	3 Credits	PCC-36

Pre-requisites: BS-115, BS-112 & CT-209

COURSE OBJECTIVES

1. To introduce fundamental principles of electrochemistry and its applications.
2. To provide theoretical and practical understanding of electrochemical cells and reactions.
3. To explore the role of electrochemistry in energy storage, sensing, and corrosion protection.
4. To expose students to modern electrochemical techniques and their applications in industry.

COURSE OUTCOMES

After completion of the course students will be able to:

1. Understand the principles and thermodynamics of electrochemical systems.
2. Analyze the kinetics of electrode processes and mass transport phenomena
3. Apply electrochemical techniques and instrumentation to characterize systems.
4. Evaluate and design electrochemical systems for energy, industrial, and sensing applications.

COURSE CONTENT

UNIT 1: Fundamentals of Electrochemistry (10 Hrs)

Electrolytes and non-electrolytes; Ionic mobility; Transport number; Electrochemical potential and chemical potential; Electrochemical cell: galvanic and electrolytic cells; Electrode potential, standard electrode potential, Nernst equation; Thermodynamics of cells – EMF, Gibbs free energy, cell work; Types of electrodes (reference, indicator, ion-selective).

UNIT 2: Electrochemical Kinetics and Mass Transport (10 Hrs)

Electrode kinetics: Butler-Volmer equation, exchange current density; Overpotentials: activation, concentration, ohmic; Mass transport mechanisms: diffusion, migration, convection; Diffusion layers and limiting current density; Tafel equation and polarization curves; Concept of double-layer and capacitance.

UNIT 3: Electrochemical Techniques and Instrumentation (12 Hrs)

Potentiometry, Coulometry, Conductometry; Voltammetry: Linear Sweep, Cyclic, Differential Pulse; Electrochemical Impedance Spectroscopy (EIS); Electrochemical workstation: electrodes, potentiostat/galvanostat; Interpretation of voltammograms and impedance plots; Application examples: sensors, batteries, fuel cells.

UNIT 4: Applications of Electrochemistry (10 Hrs)

Electrochemical energy systems: batteries, supercapacitors; Electrosynthesis and electroplating; Electrochemical corrosion: types, prevention, and protection methods; Electrochemical water splitting and CO_2 reduction; Environmental applications: pollutant sensing, wastewater treatment; Introduction to bioelectrochemistry and wearable device.

TEXT AND REFERENCES BOOKS

1. Bard, A. J., and Faulkner, L. R., *Electrochemical Methods: Fundamentals and Applications*, 2nd Edition, Wiley, 2000.
2. Daniel, C., and Hamann, C. H., *Electrochemistry*, 2nd Edition, Wiley-VCH, 2007.
3. Chatterjee, Shyamalendu, *An Introduction to Electrochemistry*, PHI Learning Pvt. Ltd., 1989.
4. Vielstich, W., Gasteiger, H., and Lamm, A., *Handbook of Fuel Cells – Fundamentals, Technology, and Applications*, Wiley, 2003.
5. Bockris, J. O'M., and Reddy, A. K. N., *Modern Electrochemistry (Volumes 1 and 2)*, 2nd Edition, Springer, 1998

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
CO2	3	3	2	2	-	-	-	-	-	1	-	1
CO3	2	3	3	3	2	1	-	-	-	1	-	2
CO4	2	2	3	3	2	1	2	1	1	1	1	2

CT-220	Biomass and Biofuel Technology	L-T-P: 3-0-0	3 Credits	PCC-37

Pre-requisites: None

COURSE OBJECTIVES

1. To understand the science and technology of biomass as an energy resource.
2. To explore biochemical, thermochemical, and chemical conversion processes of biomass.
3. To study design and operation of biogas and biofuel production systems.
4. To assess economic and environmental aspects of bioenergy systems.

COURSE OUTCOMES

After completion of the course students will be able to:

1. Understand the characteristics and types of biomass and its conversion methods.
2. Design and evaluate biogas and alcohol production systems from biomass.
3. Analyze biodiesel production processes, fuel properties, and performance.
4. Apply biomass energy concepts in land reclamation, energy plantations, and power generation.

COURSE CONTENT

UNIT 1: Biomass Resources and Conversion Pathways **(9 Hrs)**

Selection of biomass feedstock; Fundamentals of photosynthesis and classification of C3 and C4 plants; Physicochemical properties of biomass as fuel; Overview of biomass conversion routes: biochemical, chemical, thermochemical; Biochemical conversion: aerobic and anaerobic digestion of biomass.

UNIT 2: Biogas and Alcohol Production **(10 Hrs)**

Types of biogas digesters: fixed dome, floating drum, etc.**;** Design, installation, and maintenance of biogas plants**;** Utilization of biogas slurry/manure: composition and value**;** Biogas utilization: cooking, heating, and motive power generation**;** Alcohol production: feedstock selection, process flow, and distillation techniques.

UNIT 3: Biodiesel and Chemical Conversion Technologies **(12 Hrs)**

Chemical conversion: hydrolysis and hydrogenation; Biofuel production technologies: ethanol, methanol, biodiesel; Transesterification mechanism for biodiesel production; Fuel properties and quality parameters of biodiesel; Oxidation stability: induction time, rancimat method, and storage consideration.

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UNIT 4: Energy Plantations and Biomass Power **(11 Hrs)**

Concept and classification of wasteland**;** Criteria for selecting energy crops for plantations**;** Biomass utilization through energy plantations on marginal land**;** Biomass gasifiers and biogas-based power generation**;** Biofuels from plant vs. animal waste: comparative advantages and drawbacks.

TEXT AND REFERENCES BOOKS

1. Rai, G. D., *Non-Conventional Energy Sources*, 5th Edition, Khanna Publishers, 2011.
2. Sukhatme, S. P., *Solar Energy: Principles of Thermal Collection and Storage*, 3rd Edition, McGraw Hill, 2008.
3. Yadav, S. N., *Biogas Technology*, 2nd Edition, Tata McGraw-Hill, 2000.
4. Goswami, D. Yogi, *Alternative Energy in Agriculture*, 1st Edition, CRC Press, 1989.

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	-	-	-	-	2
CO2	3	3	2	1	2	2	2	-	-	-	-	2
CO3	3	3	3	2	2	2	2	-	-	-	2	3
CO4	2	2	3	2	3	2	3	-	-	2	2	3

CT-222	Hydrogen Technology	L-T-P: 3-0-0	3 Credits	PCC-38

Pre-requisites: None

COURSE OBJECTIVES

1. To introduce hydrogen as a clean energy carrier and its role in sustainable energy systems.
2. To explain various hydrogen production, storage, and transportation technologies.
3. To familiarize students with hydrogen utilization in fuel cells, combustion, and industrial processes.
4. To discuss safety, economics, and environmental aspects of hydrogen energy.

COURSE OUTCOMES

After completion of the course students will be able to:

1. Explain the role of hydrogen in sustainable energy systems and its properties.
2. Compare and analyze different hydrogen production technologies for efficiency and feasibility.
3. Evaluate hydrogen storage, transportation methods, and associated safety standards.
4. Apply hydrogen technologies in energy applications and assess their environmental and economic impact.

COURSE CONTENT

UNIT 1: Introduction to Hydrogen Economy (10 Hrs)

Hydrogen as a fuel and energy carrier; Global hydrogen roadmap and policies; Properties and advantages of hydrogen; Role in decarbonization and green energy transition; Thermodynamic and energy analysis of hydrogen systems.

UNIT 2: Hydrogen Production Technologies (12 Hrs)

Conventional methods: Steam Methane Reforming (SMR), Coal gasification; **Electrolysis:** Alkaline, PEM, Solid oxide electrolyzers; **Thermochemical and photochemical methods:** Solar water splitting, photocatalysis; **Biological methods:** Microbial electrolysis, algae-based hydrogen production; Comparison of methods based on cost, efficiency, and sustainability

UNIT 3: Hydrogen Storage and Transportation (10 Hrs)

Compressed hydrogen storage, cryogenic storage; Metal hydrides, liquid organic hydrogen carriers; Carbon-based storage materials (graphene, MOFs); Pipeline and trucking of hydrogen; Safety standards and codes for storage and transport..

UNIT 4: Hydrogen Utilization and Safety (10 Hrs)

Hydrogen in internal combustion engines and turbines; Hydrogen in fuel cells (overview of PEMFC, SOFC); Blending hydrogen with natural gas; Safety considerations: leak detection, ventilation, explosion prevention; Life cycle analysis and environmental impact.

TEXT AND REFERENCES BOOKS

1. Gupta, Ram B., *Hydrogen Fuel: Production, Transport, and Storage*, 1st Edition, CRC Press, 2008.
2. Dunn, S., and Rifkin, J., *The Hydrogen Economy: The Creation of the Worldwide Energy Web*, TarcherPerigee, 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	3	-	-	-	-	-
CO2	3	3	3	3	3	2	-	-	-	-	-	-
CO3	3	3	2	3	3	3	2	-	-	-	-	2
CO4	2	3	3	3	3	3	3	-	-	-	-	2

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

CT-258	Electrochemistry Lab	L-T-P: 0-0-3	2 Credits	AEC-4

Pre-requisites: None

COURSE OBJECTIVES

1. To provide hands-on experience with electrochemical principles and techniques relevant to energy systems.
2. To familiarize students with experimental methods for batteries, fuel cells, and corrosion studies.
3. To develop analytical skills for electrochemical measurements and data interpretation.
4. To introduce safety measures while handling electrolytes, electrodes, and high-current devices.

COURSE OUTCOMES

After completion of the course students will be able to:

1. Explain the working principles of electrochemical cells and energy storage devices.
2. Perform experiments related to electrode kinetics, corrosion, and energy systems.
3. Analyze experimental data and evaluate electrochemical parameters.
4. Apply electrochemical techniques to real-world energy and corrosion problems.

LIST OF EXPERIMENTS

1. Understanding the three electrode cell configuration
2. Determination of Cell Potential and EMF using a potentiometer.
3. Study of cyclic voltammogram
4. Conductometric Titration (acid-base, strong/weak).
5. Potentiometric Titration for redox systems.
6. Electroplating of Metal on a substrate.
7. Corrosion Rate Measurement by weight loss and electrochemical method.
8. Electrochemical Impedance Spectroscopy (EIS) – Demonstration/analysis.
9. Study of Fuel Cell Characteristics (PEM or Alkaline Fuel Cell setup)
10. Electrolysis and Faraday's Law Verification (H_2/O_2 production).
11. Charge–Discharge Characteristics of Battery (Lithium-ion or Lead-acid).

TEXT AND REFERENCES BOOKS

1. Bard, Allen J., and Faulkner, Larry R., *Electrochemical Methods: Fundamentals and Applications*, 2nd Edition, Wiley, 2000.
2. Crowl, Daniel A., and Louvar, Joseph F., *Chemical Process Safety: Fundamentals with Applications*, 3rd Edition, Pearson Education, 2011.
3. Instrument manuals for potentiostat, fuel cell, and impedance spectroscopy systems, **2024**. *(Use the latest version/manuals from the manufacturers.)*

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	3	3	-	-	-	-	-	-	2
CO4	2	2	3	3	3	-	-	-	-	-	-	2

CT-260	Fuel and Combustion Lab	L-T-P: 0-0-3	2 Credits	SEC-5

Pre-requisites: None

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

FIFTH SEMESTER

Sl.	Paper ID	Course Code	Course Name	Category Code	Basic/ Honours	Contact L – T - P	Credits
1		CT-319	Nuclear Power Engineering	PCC-39	B	3 – 0 – 0	3
2		CT-321	Materials for Energy Applications	PCC-40	B	3 – 0 – 0	3
3		CT-323	Power Electronics	PCC-41	B	3 – 0 – 0	3
4		**CT-325**	**Energy Storage Systems**	**PCC-42**	**H**	**3 – 0 – 0**	**3**
5			**Elective – I**	**PEC-5**	**B**	**3 – 0 – 0**	**3**
		MOOCs -3	**Equivalent course from *MOOCs/Swayam#***				
6		CT-357	Summer Training / Summer Project ##	AEC-5	B	0 – 0 – 0	2
7		CT-359	Power Electronics Lab	SEC-6	B	0 – 0 – 4	2
8		CT-361	**Energy Storage Lab**	**SEC-7**	**H**	**0 – 0 – 4**	**2**
			Total			**23**	**21**

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-5) List:

Sl.	Paper ID	Course Code	Course Name
1		CT-327	Electrical Machines
2		CT-329	Clean Coal and Gas Technology

CT-319	**Nuclear Power Engineering**	**L-T-P: 3-0-0**	**3 Credits**	**PCC-39**

Pre-requisites: BS-119, BS-115, BS-112 & BS-116

COURSE OBJECTIVES

1. To understand the scientific principles underlying nuclear energy generation.
2. To analyze the design and working of different types of nuclear reactors.
3. To explore fuel cycles, radiation shielding, and reactor safety.
4. To evaluate the role of nuclear power in clean energy transitions.

COURSE OUTCOMES

1. Understand the physical principles and reactor components involved in nuclear energy generation.
2. Analyze different types of nuclear reactors and power conversion cycles.
3. Evaluate nuclear fuel cycles, material challenges, and waste management systems.
4. Apply knowledge of nuclear safety and policy to environmental and energy scenarios.

COURSE CONTENT

UNIT 1: Fundamentals of Nuclear Energy (10 Hrs)

Atomic structure, isotopes, radioactivity; Nuclear fission and fusion principles; Mass–energy equivalence, binding energy; Neutron life cycle and reproduction factor; Overview of the nuclear power industry (India and global); Role of DAE, BARC, NPCIL in India's nuclear program.

UNIT 2: Nuclear Reactors and Power Generation (11 Hrs)

Classification of reactors: Thermal, Fast, Breeder; Components: core, moderator, control rods, coolant, reflector, shielding; Pressurized Water Reactor (PWR), Boiling Water Reactor (BWR), Heavy Water Reactor (PHWR); Fast Breeder Reactors (FBR) and Thorium reactors; Reactor thermodynamics and power cycles.

UNIT 3: Fuel Cycle, Materials, and Waste Management (11 Hrs)

Nuclear fuel cycle: mining, enrichment, fabrication, reprocessing; Uranium and thorium resources in India; Cladding materials, reactor structural materials; Nuclear waste classification and disposal methods; Dry cask storage, vitrification, deep geological disposal; Spent fuel management in Indian nuclear plants.

UNIT 4: Reactor Safety, Shielding & Environmental Aspects (10 Hrs)

Radiation types and biological effects; Shielding design and neutron attenuation; Reactor safety systems: SCRAM, ECCS, containment; Safety protocols (IAEA/INSAG), lessons from major accidents (TMI, Chernobyl, Fukushima); Nuclear regulation in India: AERB guidelines; Role of nuclear power in net-zero goals.

TEXT AND REFERENCES BOOKS

1. Lamarsh, J. R., and Baratta, A. J., *Introduction to Nuclear Engineering*, 3rd Edition, Pearson, 2001.
2. Glasstone, S., and Sesonske, A., *Nuclear Reactor Engineering*, 4th Edition, Springer, 1994.
3. Patel, S. B., *Nuclear Physics: An Introduction*, 1st Edition, New Age International, 1991.
4. El-Wakil, M. M., *Nuclear Power Plant Engineering*, McGraw-Hill, 1984.

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	2	2	-	-	-	-	1
CO2	3	3	3	2	2	2	1	-	-	-	-	1
CO3	2	3	2	2	2	3	2	1		1	-	2
CO4	2	2	3	2	3	3	2	1	1	1	1	3

CT-321	Materials for Energy Applications	L-T-P: 3-0-0	3 Credits	PCC-40

Pre-requisites: CT-209

COURSE OBJECTIVES

1. To understand the fundamental structure–property relationships of materials used in energy systems.
2. To study materials used in conventional and renewable energy technologies.
3. To explore the synthesis, design, and degradation of energy materials.
4. To apply knowledge of materials science in developing sustainable energy solutions.

COURSE OUTCOMES

After completion of the course students will be able to:

1. Understand the fundamental structure–property relationships in energy materials.
2. Analyze the suitability of materials for thermal and fossil energy applications.
3. Evaluate materials for energy conversion and storage technologies.
4. Explore advanced, nanostructured, and sustainable materials for future energy needs.

COURSE CONTENT

UNIT 1: Fundamentals of Materials Science (9 Hrs)

Classification of materials: metals, ceramics, polymers, composites, nanomaterials; Atomic structure and bonding, crystal systems and defects; Phase diagrams, phase transformations, and microstructure evolution; Mechanical, thermal, electrical, and optical properties of materials; Structure–property correlations for energy material

UNIT 2: Materials for Thermal and Fossil Energy Systems (10 Hrs)

High-temperature alloys for power plants and thermal applications; Refractory materials and thermal insulation; Materials for heat exchangers and boilers; Corrosion and degradation in thermal systems; Coatings for thermal protection and heat resistance.

UNIT 3: Materials for Renewable and Energy Storage Applications (12 Hrs)

Photovoltaic materials: silicon-based, perovskite, thin films; Materials for batteries: electrodes and electrolytes in Li-ion, Na-ion, solid-state batteries; Materials for supercapacitors: carbon-based, pseudocapacitive, hybrid; Fuel cell materials: catalysts, membranes, bipolar plates; Hydrogen storage materials (metal hydrides, adsorbents).

UNIT 4: Advanced & Sustainable Energy Materials (11 Hrs)

Nanomaterials and 2D materials in energy; Smart materials and phase-change materials for energy applications; Bio-inspired and green materials for energy harvesting; Degradation, failure mechanisms, and recyclability of energy materials; Characterization techniques: XRD, SEM/TEM, TGA/DSC, UV-Vis, impedance spectroscopy; Future trends: quantum materials, multifunctional materials, AI-guided material discovery.

TEXT AND REFERENCES BOOKS

1. Callister, W. D., and Rethwisch, D. G., *Materials Science and Engineering: An Introduction*, 10th Edition, Wiley, 2018.
2. Gaskell, D. R., *Introduction to the Thermodynamics of Materials*, 5th Edition, Taylor & Francis, 2008.
3. Basu, S., *Materials for Energy Conversion Devices*, Springer, 2005.
4. Nishi, Y. (Ed.), *Lithium-Ion Battery Materials and Engineering*, Springer, 2017.
5. Green, M., and Nelson, J., *Materials for Solar Energy Conversion*, CRC Press, 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	2	2	1	1	1	1	-	-	-	-	1
CO2	3	3	2	2	1	1	2	1	-	-	-	1
CO3	2	3	3	3	2	1	1	-	-	1	-	2
CO4	2	2	3	3	3	2	3	1	1	1	1	3

CT-323	Power Electronics	L-T-P: 3-0-0	3 Credits	PCC-41

Pre-requisites: IT-109 & CT-216

COURSE OBJECTIVES

1. To understand the working principles of semiconductor power devices.
2. To analyze the operation of converters, inverters, and choppers.
3. To apply power electronics in renewable energy systems, electric vehicles, and drives.
4. To enable design and control of power electronic circuits.

COURSE OUTCOMES

1. Understand characteristics and operation of power semiconductor devices.
2. Analyze and design AC-DC converters for various applications.
3. Evaluate DC-DC and DC-AC converter topologies and control techniques.
4. Apply power electronic circuits in energy systems including renewable and EVs.

COURSE CONTENT

UNIT 1: Power Semiconductor Devices (10 Hrs)

Overview of power electronics and applications; Characteristics and switching behavior of: Diodes, SCRs (Thyristors), Power BJTs, MOSFETs, IGBTs, GTOs; Static and dynamic characteristics; Device protection: snubber circuits, gate drive circuits; Thermal management and heat sinks.

UNIT 2: AC to DC Converters (Rectifiers) (10 Hrs)

Uncontrolled and controlled rectifiers (single-phase & three-phase); Half-controlled and fully controlled bridge rectifiers; Performance parameters: output voltage, current, efficiency, ripple; Input power factor and THD; Freewheeling diodes and effect of source inductance; Dual converters.

UNIT 3: DC-DC Converters and Inverters (11 Hrs)

Step-up, step-down, buck-boost, and cuk converters; Continuous and discontinuous conduction modes; Basic control methods: PWM, voltage-mode and current-mode control; Voltage Source Inverter (VSI), Current Source Inverter (CSI); Single-phase and three-phase inverters (120° and 180° conduction); PWM techniques: SPWM, SVM.

UNIT 4: Applications in Renewable and Smart Energy Systems (11 Hrs)

Power electronics in solar PV systems (MPPT, DC-DC conversion, grid-tied inverters); Power electronics in wind energy conversion systems; Role in electric vehicles: motor drives, charging circuits; UPS, SMPS, energy storage interface; Smart grid interfaces, FACTS overview; Introduction to multilevel inverters.

TEXT AND REFERENCES BOOKS

1. Rashid, M. H., *Power Electronics: Circuits, Devices and Applications*, 4th Edition, Pearson, 2013.
2. Mohan, N., Undeland, T. M., and Robbins, W. P., *Power Electronics: Converters, Applications and Design*, 3rd Edition, Wiley, 2002.
3. Bimbhra, P. S., *Power Electronics*, 5th Edition, Khanna Publishers, 2012.
4. Hart, D. W., *Power Electronics*, McGraw-Hill Education, 2010.
5. Moorthi, V. R., *Power Electronics: Devices, Circuits, and Industrial Applications*, Oxford University Press, 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	2	2	1	1	-	-	-	-	-	-	1
CO2	3	3	3	2	2	1	1	-	-	-	-	1
CO3	3	3	3	3	3	1	1	-	-	1	1	2
CO4	2	2	3	3	3	2	3	1	1	1	1	3

CT-325	Energy Storage Systems	L-T-P: 3-0-0	3 Credits	PCC-42

Pre-requisites: None

COURSE OBJECTIVES

1. To provide fundamental understanding of electrical, electrochemical, mechanical, and thermal energy storage technologies.
2. To analyze performance characteristics of various storage systems and their integration with energy sources.
3. To explore energy storage applications in grid management, electric mobility, and renewable energy.
4. To evaluate recent advances and future prospects in energy storage systems.

COURSE OUTCOMES

1. Understand various energy storage technologies and their characteristics.
2. Analyze the design and operation of battery systems and other electrochemical storage devices.
3. Evaluate mechanical, electrical, and thermal storage options for different applications.
4. Apply knowledge of energy storage integration in renewable energy, EVs, and smart grids.

COURSE CONTENT

UNIT 1: Introduction to Energy Storage **(10 Hrs)**

Need for energy storage in modern energy systems; Classification of storage systems: mechanical, electrochemical, chemical, electrical, thermal; Parameters: energy density, power density, round-trip efficiency, cycle life, self-discharge; Applications: grid support, load shifting, frequency regulation, e-mobility, off-grid systems; Energy storage economics and selection criteria.

UNIT 2: Electrochemical Storage Systems **(11 Hrs)**

Fundamentals of batteries: charge/discharge, Coulombic efficiency, SOC, DOD; Battery types and characteristics: Lead-acid, Nickel-Cadmium, Nickel-Metal Hydride, Lithium-ion (LFP, NMC), Sodium-ion, Flow batteries (Vanadium redox); Battery management systems (BMS): safety, thermal management; Recycling, degradation mechanisms, and second-life batteries.

UNIT 3: Electrical, Mechanical, and Thermal Storage **(11 Hrs)**

Supercapacitors and ultracapacitors: principles, applications; Flywheel energy storage: working, advantages, limitations; Compressed Air Energy Storage (CAES): isothermal/adiabatic systems; Pumped Hydro Energy Storage (PHES): topology, site selection; Thermal storage: sensible, latent, and thermochemical storage; Phase Change Materials (PCMs) and their integration in solar systems.

UNIT 4: Integration, Applications, and Emerging Trends **(10 Hrs)**

Hybrid storage systems: battery + supercapacitor, battery + fuel cell; Storage for solar PV and wind systems (smoothing, ramp control, black start); Role of storage in microgrids, smart grids, and electric vehicles; Hydrogen as energy storage: electrolyzers, storage, fuel cells; Policies and standards: MNRE, BIS, IEC guidelines on ESS; Future technologies: solid-state batteries, metal-air.

TEXT AND REFERENCES BOOKS

1. Dunn, B., Kamath, H., and Tarascon, J.-M., *Electrical Energy Storage for the Grid*, Science, 2011.
2. Ter-Gazarian, A., *Energy Storage for Power Systems*, IET, 2011.
3. Deshpande, R. P., *Energy Storage Technologies*, Jaico Publishing, 2014.
4. Thipse, S. S., *Energy Storage Systems*, Narosa Publishing House, 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	2	2	1	1	1	2	-	-	-	-	1
CO2	3	3	3	2	2	1	1	-	-	-	-	2
CO3	2	3	3	2	2	1	2	1	-	1	-	2
CO4	2	2	3	2	3	3	3	1	1	1	1	3

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-359	Power Electronics Lab	L-T-P: 0-0-3	2 Credits	SEC-6

Pre-requisites:

COURSE OBJECTIVES

1. To familiarize students with the characteristics of power electronic devices.
2. To develop hands-on experience in converters, inverters, and controlled rectifiers.
3. To understand the control of electric power using semiconductor devices.
4. To apply power electronics principles in renewable energy and industrial applications.

COURSE OUTCOMES

1. Understand the working characteristics of power electronic devices like SCR, MOSFET, and IGBT.
2. Analyze controlled rectifiers, inverters, and choppers through practical experiments.
3. Design and simulate basic power electronic circuits for energy applications.
4. Apply power electronic systems for renewable energy integration and motor control.

LIST OF EXPERIMENTS

1. Study of SCR Characteristics and triggering methods.
2. Study of MOSFET and IGBT Characteristics.
3. Single-phase Controlled Rectifier using SCR (half-wave & full-wave).
4. Bridge Rectifier with R, RL, and RLC loads – measure ripple factor.
5. DC Chopper Circuit – step-up and step-down operation.
6. Single-phase Inverter (voltage source inverter) – study output waveform.
7. Cycloconverter – step-down AC to AC conversion.
8. Speed Control of DC Motor using SCR or Chopper.
9. PWM Techniques for inverter output control.

TEXT AND REFERENCES BOOKS

1. Rashid, M. H., *Power Electronics: Circuits, Devices and Applications*, 4th Edition, Pearson, 2013.
2. Bimbhra, P. S., *Power Electronics*, 5th Edition, Khanna Publishers, 2012.
3. Mohan, N., *Power Electronics: Converters, Applications and Design*, 3rd Edition, Wiley, 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	-	-	3	-	-	-	-	-	-	-
CO2	3	3	3	-	3	-	-	-	-	-	-	-
CO3	2	3	3	3	3	-	-	-	-	-	-	2
CO4	2	3	3	3	3	3	-	-	-	-	-	2

CT-361	Energy Storage Lab	L-T-P: 0-0-4	2 Credits	SEC-7

Pre-requisites: None

COURSE OBJECTIVES

1. To provide hands-on experience with different types of batteries used in energy systems.
2. To study battery characteristics such as charge-discharge cycles, capacity, efficiency, and internal resistance.
3. To understand safety, thermal behavior, and degradation mechanisms in batteries.
4. To develop data analysis and interpretation skills for battery performance evaluation.

COURSE OUTCOMES

1. Understand construction, working principles, and classifications of batteries.
2. Conduct experiments to determine capacity, efficiency, and internal resistance of batteries.
3. Analyze battery performance under different operating conditions.
4. Apply knowledge of batteries in renewable energy and electric vehicle systems.

LIST OF EXPERIMENTS

1. Study of Different Types of Batteries (Lead-acid, Li-ion, Ni-MH).
2. Charge–Discharge Cycle of Lead-Acid Battery – determine capacity & efficiency.
3. Charge–Discharge Cycle of Lithium-Ion Battery – specific energy & cycle life.
4. Measurement of Internal Resistance using AC and DC methods.
5. Effect of Temperature on Battery Performance.
6. Battery Efficiency Test – Coulombic and Energy Efficiency.
7. Battery Pack Balancing and Management System (BMS) Demonstration.
8. Study of Battery Charging Methods (Constant Voltage, Constant Current).
9. Safety and Thermal Behavior Test for batteries.
10. Simulation of Battery Models using MATLAB/Simulink.

TEXT AND REFERENCES BOOKS

1. Linden, D., and Reddy, T., *Handbook of Batteries*, 4th Edition, McGraw-Hill, 2010.
2. Garche, J., *Lead-Acid Batteries for Future Automobiles*, 1st Edition, Elsevier, 2017.
3. Winter, M., and Brodd, R., *What Are Batteries, Fuel Cells, and Supercapacitors?*, 1st Edition, Wiley-VCH, 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	2	-	-	-	2	3	-	-	-	-	-
CO2	3	3	2	-	3	-	-	-	-	-	-	-
CO3	2	3	3	3	3	2	2	-	-	-	-	2
CO4	2	2	3	3	3	3	3	-	-	-	-	2

CT-327	Electrical Machines	L-T-P: 3-0-0	3 Credits	PEC-5(1)

Pre-requisites: IT-109 & BS-116

COURSE OBJECTIVES

1. To introduce the fundamentals of magnetic circuits and electromechanical energy conversion.
2. To explain the operating principles and performance of AC and DC machines.
3. To analyze machine characteristics through equivalent circuits and practical scenarios.
4. To explore the role of electrical machines in modern energy and mobility systems.

COURSE OUTCOMES

1. Understand magnetic circuits and the operating principles of electrical machines.
2. Analyze the performance and characteristics of DC machines and their applications
3. Interpret the operation and control of transformers and induction motors.
4. Apply the knowledge of synchronous and special machines to energy systems and EVs.

COURSE CONTENT

UNIT 1:Principles of Electromechanical Energy Conversion & Transformers (9 Hrs)

Magnetic circuits and losses: MMF, reluctance, hysteresis, eddy currents; Energy conversion principle, force/torque in magnetic systems; Construction and working of single-phase and three-phase transformers; Equivalent circuit, efficiency, voltage regulation; Auto-transformers and basic applications.

UNIT 2: DC Machines (12 Hrs)

Construction, types (shunt, series, compound); EMF and torque equations; Characteristics and operation of DC motors and generators; Speed control and starting methods; Applications in traction, pumps, and battery charging.

UNIT 3: Three-Phase Induction Machines (12 Hrs)

Construction and working principle; Types: squirrel cage, wound rotor; Slip, torque-slip characteristics, power stages; Starting and speed control methods; Industrial and renewable energy applications.

UNIT 4: Basics of Synchronous Machines & Special Machines (9 Hrs)

Construction and operation of synchronous generators and motors; EMF equation, phasor diagram (qualitative); Voltage regulation (syn. impedance method - basic); Principle of stepper motor and BLDC; Applications in wind turbines, EVs, robotics.

TEXT AND REFERENCES BOOKS

1. Kothari, D. P. and Nagrath, I. J., *Electric Machines*, Tata McGraw-Hill, 2004.
2. Fitzgerald, A. E., Kingsley, C., and Umans, S. D., *Electric Machinery*, 6th Edition, McGraw-Hill, 2002.
3. Bimbhra, P. S., *Electrical Machinery*, 7th Edition, Khanna Publishers, 2003.
4. Gupta, J. B., *Theory and Performance of Electrical Machines*, 14th Edition, S. K. Kataria & Sons, 2007.
5. Theraja, B. L., *Electrical Technology Vol. II*, S. Chand, 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	2	2	1	1	-	-	-	-	-	-	1
CO2	3	3	2	2	2	-	-	-	-	-	-	1
CO3	3	3	3	2	2	1	1	-	-	1	-	2
CO4	2	2	3	2	3	1	2	1	1	1	1	3

CT-329	Clean Coal and Gas Technology	L-T-P: 3-0-0	3 Credits	PEC-5(2)

Pre-requisites: None

COURSE OBJECTIVES

1. To provide fundamental knowledge of clean coal and natural gas technologies for sustainable energy production.
2. To explore emission control, gasification, and carbon capture techniques.
3. To analyze the environmental and techno-economic aspects of coal and gas utilization.
4. To evaluate the role of these technologies in India's energy transition and decarbonization goals.

COURSE OUTCOMES

1. Understand the role of clean coal and gas technologies in modern energy systems.
2. Analyze coal combustion and gasification-based power cycles and emission controls.
3. Evaluate carbon capture techniques and their environmental implications.
4. Apply knowledge of gas technologies in sustainable and hybrid energy applications.

COURSE CONTENT

UNIT 1: Introduction to Clean Coal and Gas Technologies (9 Hrs)

Global and Indian scenario of coal and gas-based power; Environmental concerns and the need for clean technologie; Overview of coal cleaning, washing, and beneficiation techniques; Classification of coal: high ash Indian coal characteristics; Role of natural gas and LNG in energy security and transition.

UNIT 2: Coal Combustion and Advanced Power Cycles (12 Hrs)

Pulverized Coal Combustion (PCC): subcritical, supercritical, ultra-supercritical; Fluidized Bed Combustion (FBC): AFBC, CFBC – working, advantages, Indian use cases; Integrated Gasification Combined Cycle (IGCC): gasifier types, syngas, HRSG; Circulating fluidized bed gasifiers; Combined Heat and Power (CHP) and cogeneration from coal/gas; Techno-economic comparison of advanced vs conventional coal technologies.

UNIT 3: Emission Control and Carbon Capture Techniques (12 Hrs)

Pollutants from coal/gas: SOx, NOx, PM, mercury, CO_2; Emission control: Electrostatic precipitator (ESP), Bag filters, FGD, SCR/SNCR; Carbon Capture Utilization and Storage (CCUS): Pre-combustion, post-combustion, oxy-fuel technologies; CO_2 compression, transport, and geological storage; Enhanced Oil Recovery (EOR) and mineral carbonation; Environmental regulations in India: CPCB norms for TPPs.

UNIT 4: Clean Gas Technologies and Future Trends (9 Hrs)

Natural gas processing: dehydration, sweetening, compression; LNG technology: liquefaction, regasification, LNG as marine and heavy transport fuel; Combined Cycle Gas Turbines (CCGT): Brayton–Rankine integration; Microturbines, fuel cells with gas reforming; Hydrogen-enriched natural gas (HENG), synthetic gas (SNG); India's policy initiatives: Ujjwala, SATAT, Hydrogen Mission, coal-to-methanol roadmap.

TEXT AND REFERENCES BOOKS

1. Miller, B. G., *Clean Coal Engineering Technology*, 1st Edition, Elsevier, 2011.
2. Speight, J. G., *The Chemistry and Technology of Coal*, 3rd Edition, CRC Press, 2012.
3. Basu, P., *Combustion and Gasification in Fluidized Beds*, 1st Edition, CRC Press, 2006.
4. Yoo, Y.-C., *Natural Gas Engineering Handbook*, 1st Edition, McGraw-Hill, 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	2	2	1	1	2	3	1	-	-	-	1
CO2	3	3	3	2	2	2	2	1	-	-	-	1
CO3	2	3	2	2	2	3	3	2	-	1	-	2
CO4	2	2	3	2	3	3	3	1	1	1	1	3

SIXTH SEMESTER

Sl.	Paper ID	Course Code	Course Name	Category Code	Basic/ Honours	Contact L – T - P	Credits
1		CT-318	Energy Audit and Management	PCC-43	B	3 – 0 – 0	3
2		**CT-320**	**Fuel cell Technology**	**PCC-44**	**H**	**3 – 0 – 0**	**3**
3		CT-322	Wind, Hydro and Ocean Technology	PCC-45	B	3 – 0 – 0	3
4		CT-324	Energy system modelling & simulation	PCC-46	B	3 – 0 – 0	3
5		CT-326	Energy conservation, recovery and management	PCC-47	B	3 – 0 – 0	3
6			**Elective - II**	**PEC-6**	**B**	**3 – 0 – 0**	**3**
		MOOCs -4	**Equivalent course from *MOOCs/Swayam#***				
7		CT-356	Seminar-II	AEC-6	B	0 – 0 – 3	2
8		**CT-360**	**Fuel cell Technology Lab**	**SEC-8**	**H**	**0 – 0 – 4**	**2**
9		CT-362	Energy system modelling & simulation Lab	SEC-9	B	0 – 0 – 3	2
Total						**28**	**24**

Elective-II (PEC-6) List:

Sl.	Paper ID	Course Code	Course Name
1		CT-328	Advanced Bio-fuel Technology
2		CT-330	Waste to Energy

CT-318	Energy Audit and Management	L-T-P: 3-0-0	3 Credits	PCC-43

Pre-requisites: None

COURSE OBJECTIVES

1. To familiarize students with energy management principles, energy auditing methods, and energy-saving opportunities.
2. To enable understanding of energy efficiency in electrical, thermal, and utility systems.
3. To equip students with the skills to perform energy audits and recommend conservation measures.
4. To create awareness about energy policies, standards, and environmental impact.

COURSE OUTCOMES

1. Understand the principles of energy management and energy audit.
2. Identify energy losses in electrical and thermal systems and suggest improvements.
3. Apply energy auditing tools and techniques to industrial systems.
4. Analyze cost-benefit aspects of energy conservation measures.

COURSE CONTENT

UNIT 1: Energy Scenario & Management Basics **(10 Hrs)**

Global and Indian energy scenario; Energy resources: Renewable and non-renewable; Energy demand and supply trends; Energy pricing and sector reforms; Basics of energy management, need for energy audit; Energy efficiency, conservation, and optimization concepts.

UNIT 2: Energy Audit Methodology **(10 Hrs)**

Types of energy audits (Preliminary and Detailed); Data collection and analysis; Instruments for energy audit (power analyzer, lux meter, flue gas analyzer, infrared thermometer, ultrasonic leak detector, etc.); Energy performance indicators; Benchmarking and performance assessment.

UNIT 3: Energy Efficiency in Systems **(12 Hrs)**

Electrical Systems: Motors, pumps, fans, compressors, transformers, power factor improvement, demand control; **Thermal Systems:** Boilers, steam distribution, furnaces, heat exchangers, waste heat recovery; HVAC systems and energy saving opportunities; Cogeneration and tri-generation systems.

UNIT 4: Energy Economics & Standards **(10 Hrs)**

Economic analysis: Payback period, NPV, IRR; Life cycle cost analysis; Energy efficiency standards and labelling; Energy policy and legal aspects (Energy Conservation Act 2001, PAT scheme, ISO 50001); Environmental impacts of energy use and carbon footprint reduction.

TEXT AND REFERENCES BOOKS

1. Bureau of Energy Efficiency, *Energy Managers & Auditors Guidebook*, 4th Edition, BEE, 2016.
2. O'Callaghan, P. W., *Energy Management*, 1st Edition, McGraw-Hill, 1993.
3. Tyagi, A. K., *Handbook on Energy Audit and Environment Management*, 1st Edition, TERI Press, 2003.
4. Doty, S., and Turner, W. C., *Energy Management Handbook*, 9th Edition, Fairmont Press, 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	2	-	-	-	2	3	2	-	-	-	-
CO2	3	3	2	-	3	-	2	2	-	-	-	-
CO3	2	3	3	3	3	2	2	-	-	-	-	2
CO4	2	2	3	3	3	3	3	-	-	-	-	2

CT-320	Fuel Cell Technology	L-T-P: 3-0-0	3 Credits	PCC-44

Pre-requisites: CT-209 & CT218

COURSE OBJECTIVES

1. Introduce the fundamental working principles and thermodynamics of fuel cells.
2. Explain the electrochemical kinetics, charge and mass transport, and design of fuel cell systems.
3. Familiarize students with characterization techniques and modelling approaches for fuel cells.
4. Discuss hydrogen production, storage, safety, and integration of fuel cells in energy systems.

COURSE OUTCOMES

1. Understand the fundamental principles, types, and efficiency of fuel cells.
2. Analyze fuel cell reaction kinetics, including overpotential and mass transport phenomena.
3. Apply fuel cell characterization and modelling techniques for performance analysis.
4. Evaluate hydrogen production, system integration, and safety in practical applications.

COURSE CONTENT

UNIT 1: Basics of Fuel Cells **(12Hrs)**

Introduction to fuel cells and hydrogen economy; Overview of fuel cells: Low and high temperature fuel cells; Fuel cell thermodynamics - heat, work potentials, prediction of reversible voltage, fuel cell efficiency.

UNIT 2: Fuel Cell Reaction Kinetics **(11 Hrs)**

Electrode kinetics, overvoltages, Tafel equation, charge transfer reaction, exchange currents, electrocatalyses - design, activation kinetics, Fuel cell charge and mass transport - flow field, transport in electrode and electrolyte.

UNIT 3: Fuel Cell Characterization **(9 Hrs)**

In-situ and ex-situ characterization techniques, I-V curve, frequency response analyses; Fuel cell modelling and system integration: - 1D model - analytical solution and CFD models.

UNIT 4: Fuel Cell Modelling and System Integration **(10 Hrs)**

Balance of plant; Hydrogen production from renewable sources and storage; safety issues, cost expectation and life cycle analysis of fuel cells.

TEXT AND REFERENCES BOOKS

1. O'Hayre, R. P., Cha, S., Colella, W., and Prinz, F. B., *Fuel Cell Fundamentals*, 1st Edition, Wiley, New York, 2006.
2. Bard, A. J., and Faulkner, L. R., *Electrochemical Methods: Fundamentals and Applications*, 2nd Edition, Wiley, New York, 2004.
3. Basu, S. (Ed.), *Fuel Cell Science and Technology*, 1st Edition, Springer, New York, 2007.
4. Liu, H., *Principles of Fuel Cells*, 1st Edition, Taylor & Francis, New York, 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	2	2	1	1	-	-	-	-	-	-	1
CO2	3	3	3	2	2	-	-	-	-	-	-	2
CO3	2	3	3	2	2	-	-	-	-	-	-	2
CO4	2	2	3	2	3	-	-	-	-	-	-	3

CT-322	Wind, Hydro and Ocean Technology	L-T-P: 3-0-0	3 Credits	PCC-45

Pre-requisites: None

COURSE OBJECTIVES

1. To understand the fundamental principles and design of hydro, ocean, and wind energy systems.
2. To familiarize students with assessment methods, components, and design criteria for renewable energy plants.
3. To analyze performance, limitations, and applications of these systems in the Indian context.

COURSE OUTCOMES

1. Explain the working principles and site selection criteria for hydro, ocean, and wind energy systems.
2. Evaluate the design and performance parameters of hydroelectric and ocean energy systems.
3. Analyze aerodynamic aspects and load calculations for wind turbines.
4. Apply knowledge to select, size, and optimize renewable energy systems for real-world scenarios.

COURSE CONTENT

UNIT 1: Hydro Energy Systems **(10 Hrs)**

Introduction to hydro-energy systems; Potential site selection and civil works; Dam size and construction aspects; Estimation of power from hydro resources; Overview of micro, mini, and small hydro systems; Turbine elements, assessment of hydro power; Selection and design criteria of turbines; Speed and voltage regulation in hydro power plants

UNIT 2: Ocean Energy Systems **(10 Hrs)**

Ocean energy resources and energy routes; Principle and working of Ocean Thermal Energy Conversion (OTEC) systems; Ocean thermal power plants – open and closed cycles; Principles of ocean wave energy and tidal energy conversion; Indian perspective on ocean and tidal energy – technical problems and limitations.

UNIT 3: Wind Energy Basics **(10 Hrs)**

Wind energy statistics and site assessment; Measurement techniques and data presentation; Wind turbine aerodynamics: Basics of aerodynamics, aerofoils and characteristics; Momentum theories and Blade Element Theory (BET); Prandtl's Lifting Line Theory; HAWT and VAWT aerodynamic principles; Wind turbine loads and steady operation.

UNIT 4: Advanced Wind Turbine Design **(12 Hrs)**

Wind turbulence, yawed operation, and tower shadow effects; Rotor sitting and selection; Annual energy output estimation; Horizontal and vertical axis wind turbine design aspects; Rotor design considerations: Number of blades, blade profile (2/3 blades), teetering, coning; Upwind vs. downwind configurations and characteristics.

TEXT AND REFERENCES BOOKS

1. Goswami, D. Y., *Principles of Solar Engineering and Renewable Energy Technologies*, 1st Edition, CRC Press, 2017.
2. Hau, E., *Wind Turbines: Fundamentals, Technologies, Application, Economics*, 3rd Edition, Springer, 2013.
3. Mittal, A. K., *Non-Conventional Energy Resources*, 1st Edition, Katson Publishing House, 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	3	-	-	-	-	-
CO2	3	3	2	-	3	-	-	-	-	-	-	-
CO3	2	3	3	3	3	2	2	-	-	-	-	2
CO4	2	2	3	3	3	3	3	-	-	-	-	2

CT-324	Energy Systems Modeling & Simulation	L-T-P: 3-0-0	3 Credits	PCC-46

Pre-requisites: None

COURSE OBJECTIVES
1. To introduce the concepts of mathematical modelling for energy systems.
2. To develop the ability to formulate and analyze models for power generation and renewable energy systems.
3. To provide skills in simulation using software tools like MATLAB/Simulink, Aspen Plus.
4. To evaluate and optimize energy system performance through case studies.

COURSE OUTCOMES
1. Understand the need, principles, and types of modelling for energy systems.
2. Develop mathematical models for conventional and renewable energy systems.
3. Simulate and analyze system performance using computational tools.
4. Apply optimization techniques for improving energy system efficiency and economics.

COURSE CONTENT
UNIT 1: Introduction to Energy System Modelling (10 Hrs)
Need and scope of modelling and simulation; Overview of energy systems: electrical, thermal, hybrid; Types of models: physical, empirical, mathematical; Classification of simulation techniques: deterministic, probabilistic, steady-state, dynamic.

UNIT 2: Mathematical Modelling of Energy Systems (10 Hrs)
Modelling of thermal systems: heat exchangers, boilers, heat storage; Modelling of electrical systems: transformers, transmission lines; Modelling of renewable energy systems: PV, wind turbines, solar thermal collectors, biomass gasifiers; Governing equations: energy balance, mass balance, thermodynamic laws.

UNIT 3: Simulation Techniques & Tools (12 Hrs)
Numerical methods for solving energy system models; Time domain and frequency domain analysis; Simulation software: MATLAB/Simulink, Aspen Plus; Case studies on solar PV, wind, and hybrid systems.

UNIT 4: Optimization of Energy Systems (10Hrs)
Objective functions: energy cost, efficiency, emissions; Linear programming, nonlinear programming, dynamic programming; Economic analysis and optimization of renewable energy systems; Multi-objective optimization and use of software (MATLAB Optimization Toolbox, GAMS).

TEXT AND REFERENCES BOOKS

1. Bejan, A., *Advanced Engineering Thermodynamics*, 4th Edition, Wiley, 2016.
2. Kalogirou, S. A., *Solar Energy Engineering: Processes and Systems*, 2nd Edition, Academic Press, 2013.
3. Bala, B. K., *Energy Systems Modelling and Policy Analysis*, 1st Edition, CRC Press, 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	2	-	-	1	2	-	-	-	-	-
CO2	3	3	3	2	2	2	2	-	-	-	-	2
CO3	3	3	3	3	3	2	3	-	-	-	-	3
CO4	2	3	3	3	3	3	3	-	-	-	-	3

CT-326	Energy Conservation, Recovery and Management	L-T-P: 3-0-0	3 Credits	PCC-47

Pre-requisites: None

COURSE OBJECTIVES

1. To impart knowledge on energy conservation principles in thermal, electrical, and process systems.
2. To explore energy recovery strategies and technologies in industrial systems.
3. To develop managerial skills for implementing energy-efficient solutions.
4. To familiarize students with energy audit practices, standards, and regulatory frameworks.

COURSE OUTCOMES

1. Understand and explain the principles, methodologies, and economics of energy conservation in industrial and commercial systems.
2. Identify, analyze, and quantify energy losses in thermal, electrical, and mechanical systems, and propose measures for recovery.
3. Apply standards, energy audit procedures, and tools to conduct preliminary and detailed energy audits.
4. Evaluate and design integrated energy management systems using case studies and modern tools for sustainable practices

COURSE CONTENT

UNIT 1: Fundamentals of Energy Conservation and Efficiency (10 Hrs)

Concept of energy, types and forms of energy, primary and secondary energy resources; Energy intensity and energy productivity; Principles of energy conservation and its need in the Indian context; Energy efficiency: definitions, energy performance indicators, benchmarking; Laws of thermodynamics in the context of energy conservation; Energy and environment linkages; role of government and policy.

UNIT 2: Energy Auditing and Instrumentation (12 Hrs)

Types of audits: preliminary, detailed and investment-grade audit; Methodology and phases of energy audit; Energy audit instruments: wattmeter, thermocouples, flue gas analyzer, infrared thermometer, tachometer, lux meter, etc.; Data collection and analysis, performance assessment methods; Case studies of industrial energy audits (e.g., boilers, pumps, compressors, lighting, motors); Energy audit standards and regulations (BEE, EC Act, ISO 50001).

UNIT 3: Energy Recovery and Waste Heat Utilization (10 Hrs)

Classification of waste heat sources (low, medium, high grade); Waste heat recovery devices: recuperators, regenerators, heat exchangers, economizers, waste heat boilers, thermoelectric converters; Pinch analysis and heat integration concepts; Energy recovery in industrial systems: furnaces, distillation columns, refrigeration units; Emerging technologies: Organic Rankine Cycle (ORC), pressure recovery turbines.

UNIT 4: Energy Management and Sustainable Practices (10Hrs)

Principles and elements of energy management; Role of energy manager; duties and responsibilities; Cost-benefit analysis of energy conservation measures; Demand-side management (DSM), peak load management; Life cycle cost analysis, financial analysis (NPV, IRR, payback); Sustainable development goals (SDGs) and energy management; Smart energy management systems and digital tools (IoT, AI, EMS platforms).

TEXT AND REFERENCES BOOKS

1. Paul O'Callaghan, *Energy Management*, McGraw-Hill.
2. B.K. Hodge, *Analysis and Design of Energy Systems*, Pearson Education.
3. S.C. Tripathy, *Electric Energy Utilization and Conservation*, Tata McGraw Hill.
4. Albert Thumann, *Handbook of Energy Audits*, Fairmont Press.
5. Y.P. Abbi & Shashank Jain, *Handbook on Energy Audit and Environment Management*, TERI Press.

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	2	1	2	-	-	-	-	-
CO2	3	3	3	2	2	2	2	-	-	-	-	2
CO3	3	2	3	3	3	2	3	-	-	-	-	3
CO4	3	2	3	3	3	3	3	-	-	-	-	3

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-360	Fuel Cell Technology Lab	L-T-P: 0-0-4	2 Credits	SEC-8

Pre-requisites: None

COURSE OBJECTIVES

1. To provide practical exposure to fuel cell working principles and performance evaluation.
2. To familiarize students with hydrogen generation, storage, and safety.
3. To develop skills for analyzing fuel cell system integration and efficiency.

COURSE OUTCOMES

1. Demonstrate the construction and operation of different types of fuel cells.
2. Evaluate performance parameters such as voltage-current characteristics and efficiency.
3. Analyze hydrogen generation and storage systems.
4. Apply safety and integration aspects of fuel cell systems in practical applications.

LIST OF EXPERIMENTS

1. **Introduction to Fuel Cell Test Setup** – Familiarization with components and instrumentation.
2. **Polarization Curve Measurement** – Obtain I-V characteristics of a PEM fuel cell.
3. **Fuel Cell Efficiency Calculation** – Evaluate efficiency at different load conditions.
4. **Effect of Temperature and Pressure** – Study the effect on fuel cell performance.
5. **Hydrogen Production via Electrolysis** – Demonstrate hydrogen generation and calculate efficiency.
6. **Hydrogen Storage Techniques** – Analysis of storage methods and pressure testing.
7. **Comparison of PEM and Alkaline Fuel Cells** – Performance and application differences.
8. **System Integration** – Fuel cell coupled with battery or solar PV for hybrid systems.

TEXT AND REFERENCES BOOKS

1. O'Hayre, R., Cha, S., Colella, W., and Prinz, F. B., *Fuel Cell Fundamentals*, 3rd Edition, Wiley, 2016.
2. Larminie, J., and Dicks, A., *Fuel Cell Systems Explained*, 2nd Edition, Wiley, 2003.
3. Horizon Fuel Cell Technologies, *User Manuals for PEM Fuel Cell Kits (e.g., Horizon, Heliocentris)*, Manufacturer Publications, Various Years.

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	2	-	-	-	-	-
CO2	3	3	2	2	3	2	2	-	-	-	-	-
CO3	2	3	3	3	3	2	2	-	-	-	-	2
CO4	2	3	3	3	3	3	3	-	-	-	-	2

CT-362	Energy System Modeling & Simulation Lab	L-T-P: 0-0-3	2 Credits	SEC-9

Pre-requisites: None

COURSE OBJECTIVES

1. To develop hands-on skills in modelling and simulation of energy systems.
2. To familiarize students with simulation software such as MATLAB, Simulink, Aspen Plus.
3. To analyze, optimize, and validate energy conversion systems using computational tools.

COURSE OUTCOMES

1. Model energy systems using computational and simulation tools.
2. Analyze the performance of renewable and conventional energy systems.
3. Simulate integrated energy systems and evaluate operational efficiency.
4. Apply optimization and techno-economic analysis for energy projects.

LIST OF EXPERIMENTS

1. Introduction to Simulation Tools – MATLAB, Aspen Plus (overview & setup).
2. Modelling Solar PV System – Energy yield estimation under varying irradiance.
3. Simulation of Wind Turbine Performance – Using power curve and wind speed data.
4. Modelling of Biomass Gasifier and CHP System – Performance analysis in Aspen Plus.
5. Simulation of a Microgrid – Load flow analysis using MATLAB/Simulink.
6. Optimization of Energy Storage – Battery sizing for hybrid systems.
7. Energy Demand Forecasting – Regression and time-series modelling in MATLAB.

TEXT AND REFERENCES BOOKS

1. Duffie, J. A., and Beckman, W. A., *Solar Engineering of Thermal Processes*, 4th Edition, Wiley, 2013.
2. HOMER Energy, RETScreen, AspenTech, *Official Software Manuals*, Manufacturer Publications, Various Years.
3. MathWorks Inc., *MATLAB/Simulink Documentation for Energy Systems*, 2022.
4. Dincer, I., *Energy Modeling and Simulation*, 1st Edition, Elsevier, 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	2	2	2	2	2	2	-	-	-	-	-
CO2	3	3	2	2	3	2	2	-	-	-	-	-
CO3	2	3	3	3	3	2	2	-	-	-	-	2
CO4	2	3	3	3	3	3	3	-	-	-	-	2

CT-328	Advanced Bio-fuel Technology	L-T-P: 3-0-0	3 Credits	PEC-6(1)

Pre-requisites:

COURSE OBJECTIVES

1. To provide a detailed understanding of biomass resources, classification, and conversion techniques.
2. To analyze thermochemical and biochemical conversion processes for energy generation.
3. To introduce technologies for producing fuels and chemicals from biomass.
4. To discuss economic, environmental, and social aspects of biomass utilization.

COURSE OUTCOMES

1. Explain biomass resources, classification, and assessment techniques.
2. Analyze thermo-chemical and biological conversion processes for energy generation.
3. Evaluate production processes of bio-fuels, biogas, and value-added chemicals.
4. Assess waste-to-energy technologies and their environmental impacts.

COURSE CONTENT

UNIT 1: Biomass Resources and Thermochemical Conversion (10 Hrs)

Biomass formation, resources, classification, and characteristics; Techniques for biomass assessment; application of remote sensing in forest assessment; biomass estimation; Thermo-chemical conversion: direct combustion, incineration, pyrolysis, gasification, and liquefaction; Economics of thermo-chemical conversion.

UNIT 2: Biological Conversion and Biogas Technology (10 Hrs)

Biodegradation and biodegradability of substrates; Biochemistry and process parameters of bio-methanation; Biogas digester types, design, and utilization; Chemical kinetics and mathematical modelling of bio-methanation; Economics and environmental impact of biogas plants.

UNIT 3: Production of Bio-fuels and Chemicals (12 Hrs)

Bioconversion of substrates into alcohol: methanol, ethanol production; Production of organic acids, solvents, amino acids, and antibiotics; Chemical conversion: hydrolysis and hydrogenation; Solvent extraction of hydrocarbons, solvolysis of wood, production of bio-crude and biodiesel; Value-added chemicals from biomass.

UNIT 4: Waste-To-Energy and Engine Applications (10 Hrs)

Waste conversion: anaerobic digestion of sewage and municipal solid waste (MSW); Direct combustion of MSW, refuse-derived fuel (RDF); Landfill gas generation and utilization for power; Gasifiers for electricity generation; Operation of spark ignition and compression ignition engines with wood gas, methanol, ethanol, and biogas.

TEXT AND REFERENCES BOOKS

1. Sarkar, S., *Fuels and Combustion*, 3rd Edition, Universities Press, 2009.
2. Drapcho, C. M., Nghiem, J. S., and Walker, T. H., *Biofuels Engineering Process Technology*, 1st Edition, McGraw-Hill, 2008.
3. Pandey, A., Hofer, R., Larroche, C., Taherzadeh, M. J., and Nampoothiri, K. M. (Eds.), *Biomass, Biofuels, and Biochemicals: Biofuels*, 1st Edition, Elsevier, 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	-	-	-	2	3	2	-	-	-	-
CO2	3	3	2	-	3	-	3	2	-	-	-	-
CO3	2	3	3	3	3	2	2	-	-	-	-	2
CO4	2	2	3	3	3	3	3	-	-	-	-	2

CT-330	Waste to Energy	L-T-P: 3-0-0	3 Credits	PEC-6(2)

Pre-requisites: None

COURSE OBJECTIVES

1. To understand the role of waste-to-energy technologies in sustainable energy production.
2. To study the characterization of municipal, industrial, and agricultural wastes for energy recovery.
3. To analyze various thermal, biochemical, and other waste conversion processes.
4. To evaluate environmental, economic, and regulatory aspects of waste-to-energy systems.

COURSE OUTCOMES

1. Explain sources, composition, and classification of solid and liquid wastes for energy recovery.
2. Analyze thermal, biochemical, and emerging waste-to-energy technologies.
3. Design and evaluate waste-to-energy systems for power and fuel production.
4. Assess environmental and economic impacts of waste-to-energy systems.

COURSE CONTENT

UNIT 1: Introduction to Waste-To-Energy (8 Hrs)

Overview of energy recovery from waste; Sources and classification of wastes: municipal, industrial, agricultural, and hazardous wastes; Characteristics of solid and liquid wastes; Waste-to-energy potential in India and global scenario; Environmental and regulatory aspects.

UNIT 2: Thermal Conversion Technologies (12 Hrs)

Incineration: principles, technologies, energy recovery; Gasification: process, gasifier types, syngas utilization; Pyrolysis: process types, products, and applications; Refuse-Derived Fuel (RDF): production and applications; Comparison of thermal conversion methods.

UNIT 3: Biochemical and Emerging Technologies (10 Hrs)

Anaerobic digestion for biogas and power generation; Landfill gas recovery and utilization; Fermentation for bioethanol from organic waste; Advanced technologies: plasma gasification, hydrothermal treatment, supercritical oxidation; Algal biomass utilization for waste treatment and bioenergy.

UNIT 4: System Design, Economics, and Sustainability (10 Hrs)

Waste segregation and pre-processing technologies; Design considerations for waste-to-energy plants; Economic feasibility: cost components, revenue streams, and policy incentives; Life cycle assessment and sustainability analysis; Case studies: Indian and global waste-to-energy plants.

TEXT AND REFERENCES BOOKS

1. Hester, R. E., and Harrison, R. M., *Waste Treatment and Disposal*, 2nd Edition, Royal Society of Chemistry, 2002.
2. Balasubramanian, M. P. P., *Energy Recovery from Waste Materials*, 1st Edition, CRC Press, 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	2	-	-	-	2	3	2	-	-	-	-
CO2	3	3	2	2	3	-	3	2	-	-	-	-
CO3	2	3	3	3	3	2	2	-	-	-	-	2
CO4	2	2	3	3	3	3	3	-	-	-	-	2

SEVENTH SEMESTER

Sl.	Paper ID	Course Code	Course Name	Category Code	Basic/ Honours	Contact L – T - P	Credits
1		**CT-423**	**Photovoltaic Conversion Technology**	**PCC-48**	**H**	**3 – 0 – 0**	**3**
2		**CT-425**	**Energy Economics, Policy and Regulation**	**PCC-49**	**H**	**3 – 0 – 0**	**3**
3		CT-427	Solar Engineering	PCC-50	B	3– 0 – 0	3
4			**Elective - III**	**PEC-7**	**B**	**3 – 0 – 0**	**3**
		MOOCs -5	**Equivalent course from *MOOCs/Swayam#***				
5			**Elective – IV**	**PEC-8**	**B**	**3 – 0 – 0**	**3**
		MOOCs -6	**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
8		CT-455	Solar Engineering Lab	SEC-13	B	0 – 0 – 3	2
			Total			**30**	**25**

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-7) List:

Sl.	Paper ID	Course Code	Course Name
1		CT-429	Nanotechnology for Energy Systems
2		CT-417	Environmental Impact Assessment

Elective-IV (PEC-8) List:

Sl.	Course Code	Paper Code	Paper
1		CT-415	Introduction to Computational Fluid Dynamics
2		CT-431	Waste Heat Recovery

CT-423	Photovoltaic Conversion Technology	L-T-P: 3-0-0	3 Credits	PCC-48

Pre-requisites: None

COURSE OBJECTIVES

1. Introduce the fundamental principles of solar cell physics and photovoltaic (PV) materials.
2. Familiarize students with solar cell fabrication technologies and design approaches.
3. Explain organic, dye-sensitized, and advanced solar cell systems.
4. Provide a comprehensive understanding of PV system design, analysis, and applications.

COURSE OUTCOMES

1. Understand the working principles, structure, and performance parameters of solar cells.
2. Explain the fabrication methods and material technologies used in solar cell manufacturing.
3. Analyze the operation and characteristics of organic, DSSC, and perovskite solar cells.
4. Design and evaluate solar PV systems for practical applications including performance prediction and maintenance.

COURSE CONTENT

UNIT 1: Solar Cell Physics **(12 Hrs)**

Solar Cell Physics, PN junction, homo and hetero-junctions, Metal-semiconductor interface, Dark and illumination characteristics, Figure of merits of solar cell, Efficiency limits, Variation of efficiency with band-gap and temperature, Efficiency measurements, High efficiency cells, Tandem structure, Junctions in Organic Solar Cells, Working and Efficiency limits.

UNIT 2: Solar Cell Fabrication Technology **(11 Hrs)**

Solar Cell Fabrication Technology, Preparation of metallurgical junction, electronic and solar grade Silicon, Production of single crystal Silicon by Czokralski (CZ) and Float Zone (FZ) methods, Procedure of masking, photolithography and etching, Design of a complete silicon, GaAs, InP solar cell; High efficiency III-V, II-VI multi-junction solar cell, a-Si-H based solar cells, Quantum well solar cell.

UNIT 3: Organic and Advanced Solar Cells **(9 Hrs)**

Organic photovoltaic materials, principle and working, exciton generation, dissociation and transport, Basic principle of DSSC, Excitonic solar cell materials, Hole and electron transport, charge dissociation and capture. Perovskites: synthesis, properties and application in Solar Cell.

UNIT 4: SPV System Design and Applications **(10 Hrs)**

SPV Applications, Centralized and decentralized SPV systems, Stand alone, hybrid and grid connected system, System installation, operation and maintenance, Solar Photovoltaic System Design, Solar cell array system analysis and performance prediction, Shadow analysis, Reliability, Solar cell array design concepts

TEXT AND REFERENCES BOOKS

1. Green, M. A., *Solar Cells: Operating Principles, Technology, and System Applications*, 1st Edition, Prentice-Hall, 1982.
2. Wenham, S. R., Green, M. A., Watt, M. E., and Corkish, R., *Applied Photovoltaics*, 2nd Edition, Routledge, 2013.
3. Solanki, C. S., *Solar Photovoltaics: Fundamentals, Technologies and Applications*, 3rd Edition, PHI Learning, 2015.
4. Boer, K., *Handbook of Physics of Thin-Film Solar Cells*, 1st Edition, Springer, 2013.
5. Kalyanasundaram, K., *Dye Sensitized Solar Cell*, 1st Edition, CRC Press, 2010.
6. Solar Energy International, *Photovoltaics: Design and Installation Manual*, 1st Edition, New Society Publishers, 2004.
7. Larry, D. P., *Solar Cells and Their Applications*, 1st Edition, Wiley, New York, 1995.

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
CO2	3	3	3	2	2	-	2	-	-	-	-	2
CO3	2	3	3	2	2	-	3	-	-	-	-	2
CO4	2	2	3	2	3	-	3	-	-	-	-	3

CT-425	Energy Economics, Policy and Regulation	L-T-P: 3-0-0	3 Credits	PCC-49

Pre-requisites: None

COURSE OBJECTIVES

1. To introduce the fundamental concepts of energy economics and its role in energy planning.
2. To understand energy pricing, market structures, and cost-benefit analysis for energy projects.
3. To study energy policies, regulations, and legal frameworks governing energy sectors in India and globally.
4. To analyze environmental, social, and sustainability aspects in energy decision-making.

COURSE OUTCOMES

1. Explain the fundamentals of energy economics and its significance in energy planning and management.
2. Analyze economic feasibility of energy projects using cost-benefit and financial tools.
3. Interpret energy policies, legal frameworks, and regulations at national and international levels.
4. Evaluate the impact of energy pricing, subsidies, and environmental policies on energy markets.

COURSE CONTENT

UNIT 1: Energy Economics Basics (10 Hrs)

Principles of economics relevant to energy: supply-demand dynamics, elasticity; Energy and economic development: linkages and trends; Energy accounting and indicators: GDP-energy correlation, energy intensity, per capita energy consumption; Time value of money, discounting, and levelized cost of energy (LCOE).

UNIT 2: Cost Analysis and Project Evaluation (12 Hrs)

Energy pricing principles: marginal cost, average cost, and tariff structures; Cost-benefit analysis for energy projects: NPV, IRR, Payback period, and sensitivity analysis; Externalities and social cost of energy; Financial and economic appraisal of renewable vs. conventional energy projects.

UNIT 3: Energy Policies and Regulatory Frameworks (10 Hrs)

Indian Energy Policy: Electricity Act 2003, National Electricity Policy, National Action Plan on Climate Change (NAPCC); Renewable Energy Development: Renewable Purchase Obligations (RPOs), Renewable Energy Certificates (RECs), Perform, Achieve, and Trade (PAT) mechanism; Role of regulatory bodies: CERC, SERCs, PNGRB; Global initiatives: Paris Agreement, SDG 7, IEA, IRENA frameworks.

UNIT 4: Energy Market Reforms and Sustainability (10 Hrs)

Power sector reforms and open access in electricity markets; Deregulation, privatization, and competition in energy markets; Energy subsidies and taxation: impact on renewable energy adoption; Carbon pricing, carbon trading, and Clean Development Mechanism (CDM); Case studies: Indian electricity pricing, international best practices.

TEXT AND REFERENCES BOOKS

1. Bhattacharyya, S. C., *Energy Economics: Concepts, Issues, Markets and Governance*, 1st Edition, Springer, 2011.
2. Bansal, R., *Energy Economics and Policy*, 1st Edition, McGraw-Hill Education, 2021.
3. Government of India, *National Electricity Policy, Electricity Act, and Renewable Energy Policies*, Ministry of Power & MNRE, Various Years.
4. International Energy Agency (IEA) and International Renewable Energy Agency (IRENA), *Reports on Energy Policies and Market Trends*, Various Publications, Various Years.

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	-	-	-	1
CO2	3	3	3	2	2	-	2	2	-	-	-	2
CO3	2	3	2	2	2	2	3	-	-	-	-	2
CO4	2	2	3	3	3	3	3	-	-	-	-	3

CT-427	Solar Engineering	L-T-P: 3-0-0	3 Credits	PCC-50

Pre-requisites: None

COURSE OBJECTIVES

1. To understand solar radiation principles and its estimation methods.
2. To study the design, performance, and applications of solar thermal systems.
3. To learn about concentrating collectors and solar energy-based devices.
4. To explore passive solar architecture and computational modelling approaches.

COURSE OUTCOMES

1. Explain solar geometry, radiation characteristics, and measurement methods.
2. Analyze the performance of flat-plate and concentrating solar collectors.
3. Design solar thermal systems for heating, cooling, and process applications.
4. Apply computational tools for solar energy system modelling and evaluate passive solar applications

COURSE CONTENT

UNIT 1: Solar Geometry & Radiation (10 Hrs)

Earth-Sun relationship, solar constant, solar spectrum; Solar angles: declination, hour angle, solar altitude and azimuth; Day length, angle of incidence on tilted surfaces; Sun-path diagrams, shadow determination; Extraterrestrial characteristics and their influence on terrestrial solar radiation; Effect of atmosphere on solar radiation; beam, diffuse and global radiation components.

UNIT 2: Flat Plate Collectors (12 Hrs)

Construction and working of flat-plate collectors, glazing materials, absorber plates; Evacuated tube collectors; air flat-plate collectors (types and applications); Performance testing: orientable test ring, series-connected test ring, intermittent output method, ASHRAE standard; Heat loss analysis: top, bottom, edge losses; overall loss coefficient calculation.

UNIT 3: Concentrating Collectors (10 Hrs)

Characteristics and classification of concentrating collectors; Tracking vs. non-tracking concentrators; Types: parabolic trough, compound parabolic, Fresnel lens, and central receiver systems; Solar furnaces and high-temperature applications.

UNIT 4: Solar Thermal Applications & Passive Systems (10 Hrs)

Solar thermal energy systems: solar still, solar cookers, solar pond; Solar passive heating and cooling: Trombe wall, roof ponds, and thermal storage; Fundamentals of greenhouse technology: design and modelling; Software tools for simulation and optimization of solar heating/cooling applications (MATLAB, TRNSYS, PVsyst).

TEXT AND REFERENCES BOOKS

1. Duffie, J. A., and Beckman, W. A., *Solar Engineering of Thermal Processes*, 4th Edition, Wiley, 2013.
2. Sukhatme, S. P., and Nayak, J. K., *Solar Energy: Principles of Thermal Collection and Storage*, 3rd Edition, Tata McGraw-Hill, 2008.
3. Kalogirou, S., *Solar Energy Engineering: Processes and Systems*, 2nd Edition, Academic Press, 2013.
4. ASHRAE, *Handbooks and Solar Collector Testing Standards*, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Various Years.

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	3	2	3	-	2	-	-	-	-	2
CO3	2	3	3	2	2	-	3	-	-	-	-	2
CO4	2	3	3	3	3	2	3	-	-	-	-	2

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

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

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	-

CT-455	Solar Engineering Lab	L-T-P: 0-0-3	2 Credits	SEC-13

Pre-requisites:

COURSE OBJECTIVES

1. To provide hands-on experience with solar thermal and photovoltaic systems.
2. To measure, analyze, and interpret solar energy parameters and system performance.
3. To develop skills for solar energy system design and performance evaluation using experimental and computational tools.

COURSE OUTCOMES

1. Demonstrate the ability to measure solar radiation and understand solar geometry.
2. Evaluate the performance of flat-plate and concentrating solar collectors.
3. Analyze solar PV characteristics and compute efficiency.
4. Apply experimental data for sizing and modelling solar thermal/PV systems.

LIST OF EXPERIMENTS

1. Measurement of Solar Radiation: Using Pyranometer and Sunshine Recorder, Calculation of global and diffuse radiation.
2. Determination of Solar Angles and Sun Path: Construction of solar chart for given latitude.
3. Performance Test on Flat Plate Collector: Calculation of efficiency and heat loss coefficients.
4. Testing of Evacuated Tube Collector: Compare performance with flat plate collector.
5. Experiment on Concentrating Collector (Parabolic Trough): Estimation of thermal efficiency and concentration ratio.
6. Solar Water Heater Performance Analysis: Heat gain and storage efficiency evaluation.
7. Performance Test on Solar Cooker / Solar Still: Estimation of thermal efficiency and water distillation rate.
8. PV Module Characteristics: Plot I–V and P–V curves under varying irradiation levels.
9. Effect of Tilt Angle on PV Performance: Experiment with different inclinations and orientations.

SUGGESTED EQUIPMENT

1. Pyranometer, Pyrheliometer, Sunshine Recorder.
2. Flat Plate Collector, Evacuated Tube Collector, Parabolic Trough Collector.
3. Solar Water Heater, Solar Cooker, Solar Still.
4. PV Panels (Monocrystalline and Polycrystalline) with Inverter and Battery Setup.
5. Data Logger for solar radiation and temperature.

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	2	3	-	2	2	-	-	-	2
CO3	2	3	3	3	2	-	3	-	-	-	-	2
CO4	2	3	3	3	3	2	3	-	-	-	-	2

CT-429	Nanotechnology for Energy Systems	L-T-P: 3-0-0	3 Credits	PEC-7(1)

Pre-requisites:

COURSE OBJECTIVES

1. To introduce fundamental principles of nanoscience and nanotechnology relevant to energy applications.
2. To explain synthesis, characterization, and properties of nanomaterials for energy conversion and storage.
3. To familiarize students with nanotechnology applications in solar cells, fuel cells, batteries, supercapacitors, and hydrogen technology.
4. To develop an understanding of sustainability, environmental impact, and economic considerations of nanotechnology in energy systems.

COURSE OUTCOMES

1. Explain fundamental concepts of nanotechnology and its role in energy applications.
2. Identify synthesis techniques and characterize nanomaterials for energy conversion and storage devices.
3. Analyze nanostructured materials in solar, fuel cells, hydrogen storage, and thermal systems.
4. Evaluate environmental, safety, and economic aspects of nanotechnology in sustainable energy systems.

COURSE CONTENT

UNIT 1: Introduction to Nanotechnology and Energy Systems **(10 Hrs)**

Basics of nanoscience: Size effects, quantum confinement, surface-to-volume ratio; Types of nanomaterials: nanoparticles, nanowires, nanotubes, quantum dots, 2D materials; Energy demand and role of nanotechnology in renewable energy; Nanotechnology for sustainability and carbon footprint reduction.

UNIT 2: Synthesis and Characterization of Nanomaterials **(10 Hrs)**

Top-down and bottom-up approaches: Ball milling, lithography, chemical vapor deposition (CVD), sol-gel, hydrothermal, green synthesis; Surface functionalization and modification for energy applications; Characterization techniques: XRD, SEM, TEM, AFM, BET, UV-Vis spectroscopy; Thermal and electrochemical characterization for energy materials.

UNIT 3: Nanotechnology in Energy Conversion and Storage **(12 Hrs)**

Solar Energy: Nanostructured materials for PV cells (Si, perovskite, dye-sensitized solar cells), quantum dot solar cells; Fuel Cells:Nanocatalysts for electrodes, membrane modification, enhanced proton conductivity; Hydrogen Storage: Metal hydrides, carbon nanostructures, MOFs; Thermal Systems: Nanofluids for heat transfer enhancement, nano-coatings for thermal collectors.

UNIT 4: Advanced Energy Devices and Sustainability Issues **(10 Hrs)**

Nanotechnology in batteries (Li-ion, solid-state) and supercapacitors; Nano-enabled sensors for energy monitoring and control; Environmental and health impacts of nanomaterials: safety regulations, recycling; Economic feasibility, scalability, and commercialization challenges; Future trends: Nanotechnology for green hydrogen, flexible solar cells, energy harvesting.

TEXT AND REFERENCES BOOKS

1. Hornyak, G. L., Dutta, J., Moore, J., and Tibbals, H. F., *Introduction to Nanoscience and Nanotechnology*, 2^{nd} Edition, CRC Press, 2016.
2. Kalogirou, S., *Nanotechnology for Energy Sustainability*, 1^{st} Edition, Elsevier, 2017.
3. Rao, C. N. R., *Nanomaterials and Energy Applications*, 1^{st} Edition, Springer, 2017.
4. Kelsall, A. C., Hamley, I. W., and Geoghegan, M., *Nanotechnology in Energy Systems*, 1^{st} Edition, Taylor & Francis, 2005.
5. IEEE and Elsevier, *Recent Articles from Journals: Nano Energy, Renewable Energy, Journal of Power Sources*, Various Issues, Various Years.

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	-	-	-	2
CO2	3	3	3	3	3	-	2	-	-	-	-	2
CO3	2	3	3	3	3	2	3	-	-	-	-	2
CO4	2	3	3	3	3	3	3	3	-	-	-	3

CT-417	Environmental Impact Assessment	L-T-P: 3-0-0	3 Credits	PEC-7(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*, 1st Edition, 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-415	Introduction to Computational Fluid Dynamics	L-T-P: 3-0-0	3 Credits	PEC-8 (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*, 1st Edition, 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*, 1st Edition, 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-431	Waste Heat Recovery	L-T-P: 3-0-0	3 Credits	PEC-8(2)

Pre-requisites: None

COURSE OBJECTIVES

1. To explain sources and classification of waste heat in industrial systems.
2. To teach principles, equipment, and technologies for waste heat recovery.
3. To provide design methodology for heat recovery systems and integration techniques.
4. To introduce economic analysis and environmental considerations for waste heat utilization.

COURSE OUTCOMES

1. Identify sources of waste heat and analyze its impact on energy efficiency.
2. Explain working principles of various waste heat recovery equipment and technologies.
3. Design and evaluate waste heat recovery systems considering thermodynamic and economic aspects.
4. Assess environmental and sustainability benefits of waste heat recovery in industrial applications.

COURSE CONTENT

UNIT 1: Fundamentals of Waste Heat Recovery **(08 Hrs)**

Introduction: Definition, classification, and importance of waste heat recovery; Sources of waste heat in process industries, power plants, and transportation systems; Estimation of waste heat quantity and quality; Energy conservation principles and exergy analysis for waste heat.

UNIT 2: Waste Heat Recovery Equipment **(12 Hrs)**

Heat exchangers: Shell-and-tube, plate, recuperators, and regenerators; Heat pipes and heat wheels; Waste heat boilers and economizers; Heat pumps and thermo-compressors for low-grade heat recovery; Performance evaluation of waste heat recovery devices.

UNIT 3: Advanced Waste Heat Recovery Techniques **(10 Hrs)**

Organic Rankine Cycle (ORC) and Kalina cycle for low-temperature heat utilization; Thermoelectric generators (TEGs) and phase change material-based storage; Combined heat and power (CHP) and cogeneration systems; Integration of waste heat recovery with renewable systems; Case studies from chemical, cement, steel, and automobile industries.

UNIT 4: Design, Economics, and Sustainability **(12 Hrs)**

Design methodology for heat recovery systems; Economic analysis: Payback period, life-cycle cost analysis, and incentives; Environmental and sustainability benefits; Challenges in waste heat recovery: Fouling, corrosion, material selection, and maintenance; Future trends: AI and IoT-based monitoring, energy cascading.

TEXT AND REFERENCE BOOKS

1. Ganapathy, V., *Industrial Boilers and Heat Recovery Steam Generators*, 1st Edition, CRC Press, 2003.
2. Baukal, C. E., *Waste Heat Recovery: Principles and Practices*, 1st Edition, CRC Press, 2013.
3. Sarkar, D., *Thermal Power Plant: Design and Operation*, 1st Edition, Elsevier, 2015.
4. Bureau of Energy Efficiency, *Energy Efficiency in Thermal Utilities – BEE Manuals*, 4th Edition, BEE, 2016.
5. Elsevier, *Recent Papers in Applied Thermal Engineering, Energy Conversion and Management*, Various Issues, Various Years.

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	-	-	-	-	3
CO2	3	3	3	2	3	-	2	-	-	-	-	2
CO3	2	3	3	3	3	-	3	-	-	-	-	3
CO4	2	3	3	3	3	3	2	2	2	-	-	3

EIGHTH SEMESTER

Sl.	Paper ID	Course Code	Course Name	Category Code	Basic/ Honours	Contact L – T - P	Credits
1		CT-406	Analytical Methods in Engineering	PCC-26	B	3 – 0 – 0	3
2		CT-410	Power Generation, Transmission and Utilization	PCC-51	B	4– 0 – 0	4
3		CT-412	Fundamentals of Electrical Vehicle Technology	PCC-52	B	4– 0 – 0	4
4		**CT-414**	**Advanced Power Electronics for Renewable Energy Systems**	**PCC-53**	**H**	**4 – 0 – 0**	**4**
5		CT-416	Waste to Bio-energy	PCC-54	B	3 – 0 – 0	3
6		CT-450	Analytical Methods in Engineering Lab	PCC-28	B	0 – 0 – 3	2
7		CT-452	Major Project	PW-2	B	0 – 0 – 24	12
8		CT-454	Waste to Bio-energy Lab	PCC-55	B	0 – 0 – 3	2
			Total			**48**	**34**

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

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.
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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-410	Power Generation, Transmission and Utilization	L-T-P: 4-0-0	4 Credits	PCC-51

Pre-requisites:

COURSE OBJECTIVES

1. To introduce different methods of electrical power generation and their characteristics.
2. To explain power transmission systems, components, and line design.
3. To study power distribution, utilization, and electrical energy management.
4. To provide an overview of safety, economic, and environmental aspects of power systems.

COURSE OUTCOMES

1. Explain various power generation methods and their operational characteristics.
2. Analyze power transmission and distribution systems with design considerations.
3. Evaluate the performance of different electrical equipment used in power utilization.
4. Apply concepts of power system operation for efficient energy management and sustainability.

COURSE CONTENT

UNIT 1: Power Generation Systems (12Hrs)

Conventional Generation: Thermal power plants – layout, major components, and efficiency improvement; Hydro power plants – site selection, components, types of turbines; Nuclear power plants – basics, reactors, safety considerations. **Non-Conventional Generation:** Solar, wind, biomass, and geothermal-based power generation overview; Cogeneration and combined cycle systems.

UNIT 2: Power Transmission (14Hrs)

Power system structure: generation, transmission, and distribution; High voltage AC and DC transmission systems; Transmission line parameters: resistance, inductance, capacitance calculations; Performance of transmission lines: efficiency, voltage regulation; Corona, insulators, and mechanical design of transmission lines.

UNIT 3: Power Distribution and Utilization (13Hrs)

Types of distribution systems: radial, ring main, interconnected; Power factor and its improvement methods; Electrical drives: types, selection, and applications in industry; Electric heating: resistance, induction, and dielectric heating; Electric welding, electrolysis, and traction systems overview.

UNIT 4: System Operation, Economics and Safety (15Hrs)

Load curves, load factor, diversity factor, demand factor; Economic operation of power plants: unit commitment, load dispatch; Tariff systems and cost analysis; Safety in power systems and earthing methods; Environmental issues: emissions, renewable integration, smart grids.

TEXT AND REFERENCE BOOKS

1. Wadhwa, C. L., *Generation, Distribution and Utilization of Electrical Energy*, 3rd Edition, New Age International, 2011.
2. Gupta, J. B., *A Course in Power Systems*, 1st Edition, Katson Publishing House, 2013.
3. Nagrath, I. J., and Kothari, D. P., *Modern Power System Analysis*, 4th Edition, McGraw-Hill, 2011.
4. Gupta, B. R., *Power System Analysis and Design*, 1st Edition, S. Chand, 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	2	-	2	-	-	-	-	3
CO2	3	3	3	2	3	-	2	-	-	-	-	2
CO3	2	3	3	3	3	-	3	-		-	-	3
CO4	2	3	3	3	3	3	2	2	2	-	-	3

CT-412	Fundamentals of Electrical Vehicle Technology	L-T-P: 4-0-0	4 Credits	PCC-52

Pre-requisites: None

COURSE OBJECTIVES

1. To introduce the basic principles of electric vehicles and hybrid electric vehicles.
2. To understand EV architectures, components, and energy storage systems.
3. To analyze power electronics, drive systems, and charging infrastructure.
4. To discuss recent developments, safety, standards, and environmental impacts

COURSE OUTCOMES

1. Explain the fundamental concepts of electric and hybrid electric vehicles.
2. Describe battery technologies, energy management, and charging systems.
3. Analyze EV components, power electronics converters, and drive systems.
4. Evaluate safety, policy, and sustainability aspects of EV technology.

COURSE CONTENT

UNIT 1: Introduction to Electric Vehicles (13 Hrs)

Overview of transportation systems and electrification; Types of electric vehicles: BEV, HEV, PHEV, FCEV – architecture and configurations; EV vs. IC engine vehicle: performance, efficiency, emissions; Global and Indian EV market trends, policies, and government initiatives (FAME scheme).

UNIT 2: Energy Storage and Battery Management (14 Hrs)

Types of batteries: Lead-acid, NiMH, Li-ion – characteristics and comparison; Battery modelling: capacity, SOC, SOH estimation; Battery thermal management and safety issues; Charging systems: slow, fast, and ultra-fast charging; Wireless charging and V2G technology.

UNIT 3: Power Electronics and Drive Systems (12 Hrs)

EV drive train components: traction motor requirements; Types of electric motors: DC, induction, PMSM, BLDC; Power converters: DC-DC, DC-AC inverters for motor control; Regenerative braking systems; Controller strategies: torque control, speed control, energy optimization.

UNIT 4: Advanced Topics and Sustainability (15 Hrs)

EV charging infrastructure and standards: CCS, CHAdeMO, Bharat DC/AC; Safety standards and certifications for EV components; Environmental and life-cycle analysis of EVs; Future technologies: solid-state batteries, hydrogen fuel cell EVs, AI in EV control; Economic feasibility and challenges in EV adoption.

TEXT AND REFERENCE BOOKS

1. Larminie, J., and Lowry, J., *Electric Vehicle Technology Explained*, 2nd Edition, Wiley, 2012.
2. Ehsani, M., Gao, Y., Gay, S. E., and Emadi, A., *Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design*, 2nd Edition, CRC Press, 2009.
3. Husain, I., *Electric and Hybrid Vehicles: Design Fundamentals*, 2nd Edition, CRC Press, 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	-	2	-	-	-	-	3
CO2	3	3	3	2	3	-	2	-	-	-	-	2
CO3	2	3	3	3	3	-	3	-	-	-	-	3
CO4	2	3	3	3	3	3	2	2	2	-	-	3

CT-414	Advanced Power Electronics for Renewable Energy Systems	L-T-P: 4-0-0	4 Credits	PCC-53

Pre-requisites:

COURSE OBJECTIVES

1. To provide an in-depth understanding of advanced power electronic converters for renewable integration.
2. To analyze control strategies for grid-connected and standalone systems.
3. To introduce power quality, reliability, and smart grid integration concepts.
4. To discuss real-time implementation, standards, and future trends in power electronics for energy systems.

COURSE OUTCOMES

1. Explain advanced power electronic converter topologies for renewable energy applications.
2. Design and analyze converters for solar PV, wind, and energy storage systems.
3. Apply advanced control techniques for grid integration and power quality improvement.
4. Evaluate challenges and future trends in renewable energy-based power electronic systems.

COURSE CONTENT

UNIT 1: Power Electronic Converters for Renewable Energy Systems (13 Hrs)

Review of basic converters: DC–DC, DC–AC, AC–DC, and AC–AC; Advanced topologies: Multilevel inverters (diode-clamped, flying capacitor, cascaded H-bridge); Modular multilevel converters (MMC) for HVDC and grid-connected renewables; Resonant and soft-switching converters for high-efficiency applications.

UNIT 2: Solar and Wind Power Conversion Systems (14 Hrs)

MPPT techniques: Perturb & Observe, Incremental Conductance, Fuzzy Logic-based control; PV interfacing converters: Buck, Boost, SEPIC, and isolated DC-DC converters; Wind energy conversion systems: DFIG, PMSG, and full-converter-based systems; Grid synchronization of renewable sources: PLL techniques and standards.

UNIT 3: Energy Storage Integration and Control (12 Hrs)

Battery interfacing converters and bidirectional converters for storage systems; Supercapacitor and fuel cell integration using DC–DC converters; Control of hybrid renewable systems using power electronics; Real-time control strategies: PWM techniques (SPWM, SVPWM), current and voltage controllers.

UNIT 4: Power Quality, Standards, and Future Trends (15 Hrs)

Power quality issues in renewable integration: harmonics, voltage fluctuations, reactive power compensation; Active and passive power filters using power electronics; Grid codes and IEEE standards for renewable energy interfacing; Role of FACTS and HVDC in renewable energy transmission; Smart inverters, digital control using DSP and FPGA, AI/IoT for power electronics in smart grids.

TEXT AND REFERENCE BOOKS

1. Mohan, N., *Power Electronics: Converters, Applications, and Design*, 3rd Edition, Wiley, 2003.
2. Luo, F. L., and Ye, H., *Advanced DC/DC Converters*, 1st Edition, CRC Press, 2003.
3. Bose, B. K., *Power Electronics and Motor Drives: Advances and Trends*, 1st Edition, Elsevier, 2006.
4. Rashid, M. H. (Ed.), *Power Electronics Handbook*, 4th Edition, Academic Press, 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	-	2	2	-	2	-	-	-	-	3
CO2	3	3	3	2	3	-	2	-	-	-	-	2
CO3	2	3	3	3	3	-	3	-	-	-	-	3
CO4	2	3	3	3	3	3	2	2	2	-	-	3

CT-416	Waste to Bio-Energy	L-T-P: 3-0-0	3 Credits	PCC-54

Pre-requisites: Nil

COURSE OBJECTIVES
To provide students with essential knowledge and skills in biofuel production, covering feedstocks, conversion technologies, reactor systems, purification methods, and industrial applications with a focus on sustainability.

COURSE OUTCOMES
1. To identify and classify biofuel types and their feedstocks.
2. Understand pretreatment, production pathways, and biofuel chemistry.
3. Design bioreactors and evaluate purification techniques.
4. To analyze industrial-scale biofuel production.

COURSE CONTENT
UNIT 1 **(10 Hrs)**
Biofuels Classification (1st, 2nd, & 3rd generation); Types of Biofuels: Bioethanol, Biodiesel, Biogas, Biohydrogen, Bio-oil, Syngas, Algal biofuels); Characterization of biofuels: Testing for viscosity, flash point, calorific value, FFA, alcohol content; Global and Indian status of biofuel production and policy initiatives (e.g., E20, SATAT, Bioenergy missions)

UNIT 2 **(10 Hrs)**
Biomass feedstocks: Edible and non-edible oils, lignocellulosic biomass, food/agro-industrial wastes; Selection criteria for feedstocks; Pretreatment Methods: Physical (milling, steam explosion), Chemical (acid/alkali hydrolysis), Biological (fungal, enzymatic).

UNIT 3 **(10 Hrs)**
Biochemical Conversion Routes:Fermentation (bioethanol, butanol), Anaerobic digestion (biogas), Enzymatic transesterification (biodiesel), Photo-fermentation (biohydrogen); Biogas enrichment; Microbial reaction mechanisms and metabolic pathways and process parameters affecting yield and kinetics.

UNIT 4 **(12 Hrs)**
Batch, fed-batch, and continuous fermentative production methods; Bioreactor configurations and design considerations for biofuels, Instrumentation & control in bioreactors; Purification methods; Scale-up techniques for industrial production of biofuels.

TEXT AND REFERENCE BOOKS
1. Mousdale, D. M., *Biofuels: Biotechnology, Chemistry and Sustainable Development*, 1st Edition, CRC Press, 2010.
2. Ray, R. C., and Ramachandran, S. (Eds.), *Sustainable Bioenergy Production: An Integrated Approach*, 1st Edition, CRC Press, 2021.
3. Demirbas, A., *Biofuels: Securing the Planet's Future Energy Needs*, 1st Edition, Springer, 2009.
4. Nelson, D. L., and Cox, M. M., *Lehninger Principles of Biochemistry*, 7th Edition, W. H. Freeman, 2017.
5. Pandey, A., Larroche, C., Dussap, C. G., Gnansounou, E., and Ricke, S. C. (Eds.), *Biofuels: Alternative Feedstocks and Conversion Processes for the Production of Liquid and Gaseous Biofuels*, 1st Edition, Academic Press, 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	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

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	-

CT-454	Waste to Bio-energy Lab	L-T-P: 0-0-3	2 Credits	PCC-55

Pre-requisites:

COURSE OBJECTIVES

1. To develop practical skills in the production and characterization of biofuels such as biogas, biodiesel, and bioethanol from various biomass sources.
2. To train students in the operation of bioreactors and fermentation systems used in bioenergy generation, including monitoring and optimization of process parameters.
3. To analyze the microbial and enzymatic processes involved in biomass degradation and biofuel production.
4. To evaluate different lignocellulosic and algal feedstocks for their potential in energy generation.

COURSE OUTCOMES

1. To Gain proficiency in biofuel fermentation techniques
2. Operate and monitor bioprocess systems for ethanol and biogas
3. Analyze microbial performance and fuel product quality.
4. Apply integrated bioprocess knowledge for real-world energy applications.

LIST OF EXPERIMENTS

1. Media preparation and sterilization for microbial fermentation.
2. Batch fermentation for bioethanol production using Saccharomyces cerevisiae.
3. Cell biomass and ethanol quantification (gravimetric + colorimetric/density methods).
4. Distillation and recovery of bioethanol.
5. Enzymatic hydrolysis of lignocellulosic biomass using cellulases.
6. Reducing sugar estimation (DNS method).
7. Fermentation of hydrolyzed biomass to butanol.
8. Anaerobic digestion of organic waste for biogas production
9. Gas collection and estimation of methane content (alkaline trap/displacement method)
10. Operation of a lab-scale stirred tank bioreactor (STR)
11. Microbial growth kinetics and Monod model fitting
12. Production of lipase enzyme for biodiesel synthesis.
13. Microscopy and staining of fermenting microbes (yeast, bacteria).

TEXT AND REFERENCES BOOKS

1. Stanbury, P. F., Whitaker, A., and Hall, S. J., *Principles of Fermentation Technology*, 3rd Edition, Academic Press (Elsevier), 2016.
2. Shuler, M. L., and Kargi, F., *Bioprocess Engineering: Basic Concepts*, 3rd Edition, Pearson Education, 2017.
3. El-Mansi, E. M. T., Bryce, C. F. A., Demain, A. L., and Allman, A. R., *Fermentation Microbiology and Biotechnology*, 5th Edition, CRC Press (Taylor & Francis), 2018.
4. Dahiya, A., *Bioenergy: Biomass to Biofuels*, 2nd Edition, Academic Press (Elsevier), 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	3	1	2	1	2	2	1	1
CO2	3	3	3	1	3	1	2	2	1	2	1	2
CO3	2	3	3	3	3	1	2	1	2	2	1	2
CO4	2	3	3	3	3	3	2	2	2	2	1	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.