P P SAVANI UNIVERSITY

SCHOOL OF ENGINEERING

CHEMICAL ENGINEERING

SYLLABUS BOOK

AY 2026-27

INSTITUTE VISION
To emerge as an Institute of Excellence by imparting value-based education aided with Research, Innovation and Entrepreneurial skills.

INSTITUTE MISSION	
1	To impart the holistic engineering education of highest quality & prepare socially responsible professionals with entrepreneurial skills.
2	To prepare value-aided engineering professionals to meet up global industry requirements by imparting cutting edge professional education.
3	To inculcate the attitude of research and innovation among the stake holders through experiential and project-based teaching-learning pedagogy.
4	To acquire global talent pool by providing world class amenities for teaching, learning & research.

Graduates will demonstrate ability to:

PEO No	PROGRAMME EDUCATIONAL OBJECTIVES
PEO 1	Solve real-world engineering problems, design and develop innovative and cost-effective solutions exhibiting engineering skills/fundamentals to cater needs of society.
PEO 2	Excel in Industry/technical profession, higher studies, and entrepreneurship exhibiting comprehensive competitiveness.
PEO 3	Exhibit professional ethics & values, effective communication, teamwork, multidisciplinary approach, and ability to relate engineering issues to broader societal framework.

PO No	PROGRAMME OUTCOMES
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, review research literature, and analyse 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 specified needs with appropriate consideration for public health & safety, cultural, societal and environmental considerations.
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis & interpretation of data, and synthesis of information to provide valid conclusions for complex problems.
PO 5	**Engineering Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern engineering & IT tools including prediction and modelling to engineering activities, with an understanding of their limitations.
PO 6	**The Engineer and The World:** Apply reasoning informed by contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to professional engineering practice; understand the impact of engineering solutions in societal and environmental contexts, and demonstrate knowledge of, and need for, sustainable development.
PO 7	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice.
PO 8	**Individual and Collaborative Team Work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO 9	**Communication:** Communicate effectively on engineering activities with the engineering community and with society at large--such as being able to write reports, design documentation, make effective presentations and give/receive instructions.
PO 10	**Project Management and Finance:** Demonstrate knowledge and understanding of engineering and management principles and apply these to one's work, as a member or leader in a team in a multidisciplinary environment to manage projects.
PO 11	**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.

PSO No	PROGRAMME SPECIFIC OUTCOMES (PSO)
PSO 1	Acquire and apply industry centric skills in the field of Chemical Engineering for the benefit of society.
PSO 2	Develop an attitude to accept global challenges and apply Chemical Engineering knowledge for solving engineering problems related to core and interdisciplinary fields.
PSO 3	Demonstrate and develop the appropriate solutions of the complex level of Chemical Engineering design-based problems to meet the specified needs and overall sustainability of the processes, considering the necessary approaches of safety, health hazards, societal and environmental factors.

Credit Guidelines (General)

One (1) credit represents 30 hours of learning, comprising an appropriate combination of Theory, Practical, Tutorial, Project, Group Discussion, Case Study, Field Visit, Presentation, Assignment, Term Work, Self-Learning, and other curriculum-approved learning activities.

CO-PO Mapping Guidelines

Mapping Level	%age Mapping	Indicator
0	0	No Mapping
1	0-33	Low Level (Slightly Mapped)
2	33-66	Medium Level (Moderately Mapped)
3	>66	High Level (Strongly Mapped)

Syllabus Book

P P Savani University

School of Engineering

Effective From: 2026-27

Authored by: P P Savani University

CONTENT

PPSU
P P SAVANI UNIVERSITY
NAAC ACCREDITED A+ GRADE

School of Engineering

FIRST YEAR M.TECH (2026-27)

P P SAVANI UNIVERSITY

SCHOOL OF ENGINEERING

TEACHING & EXAMINATION SCHEME FOR FIRST YEAR M.TECH. CHEMICAL ENGINEERING PROGRAMME AY: 2026-27

Sem	Course Code	Course Title	Offered By	Teaching Scheme: Direct Contact Hours: Theory	Practical	Tutorial	Indirect Contact Hours: Project	GD/CS/FV/PPT	Assignment	Term Work	Self Learning	Total	Credit	Examination Scheme: Theory CE/ESE	Practical CE/ESE	Tutorial CE/ESE	Project CE/ESE	GD/CS/FV/PPT CE/ESE	Assignment CE/ESE	Term Work CE/ESE	Self Learning CE/ESE	Total CE/ESE
1	SOECH7010	Research Methodology and Ethics	CH	45	0	30	0	0	30	0	15	120	4	30 50	0	30 50	0	0	20 00	0	20 00	100 100
	SOECH7810	Research Project-I	CH	0	0		240	60	0	0	60	360	12	0	0		100 100	00 100	0	0	100 00	200 200
		Elective Course-I	CH																			
	SOECH7510	Physico-Chemical Techniques for Wastewater Treatment	CH	45	0	30	0	0	15	0	30	120	4	30 50	0	30 50	0	0	20 00	0	20 00	100 100
	SOECH7520	Environmental Engineering and Pollution Control	CH	45	0	30	0	0	15	0	30	120	4	30 50	0	30 50	0	0	20 00	0	20 00	100 100
	SOECH7530	Environmental Monitoring, Quality Assessment & Analysis	CH	45	0	30	0	0	15	0	30	120	4	30 50	0	30 50	0	0	20 00	0	20 00	100 100
		Elective Course-II	CH																			
	SOECH7540	Applied Environmental Engineering	CH	45	0	30	0	0	15	0	30	120	4	30 50	0	30 50	0	0	20 00	0	20 00	100 100
	SOECH7550	Fuel Science and Combustion Technology	CH	45	0	30	0	0	15	0	30	120	4	30 50	0	30 50	0	0	20 00	0	20 00	100 100
	SOECH7560	Optimization Techniques in Chemical Engineering	CH	45	0	30	0	0	15	0	30	120	4	30 50	0	30 50	0	0	20 00	0	20 00	100 100
											Total	**720**	**24**									**1000**
	SOECE7010	Computational Research Techniques	CE	45	0	30	0	0	30	0	15	120	4	30 50	0	30 50	0	0	20 00	0	20 00	100 100
	SOECH7820	Research Project-II	CH	0	0	0	240	60	0	0	0	300	12	0	0	0	100 100	00 100	0	0	0	200 200

P P SAVANI UNIVERSITY																						
SCHOOL OF ENGINEERING																						
TEACHING & EXAMINATION SCHEME FOR FIRST YEAR M.TECH. CHEMICAL ENGINEERING PROGRAMME AY: 2026-27																						
Sem	Course Code	Course Title	Offered By	Teaching Scheme										Examination Scheme								
				Direct Contact Hours			Indirect Contact Hours					Total	Credit	Theory	Practical	Tutorial	Project	GD/CS/FV/PPT	Assignment	Term Work	Self Learning	Total
				Theory	Practical	Tutorial	Project	GD/CS/FV/PPT	Assignment	Term Work	Self Learning			CE/ESE	CE/ESE	CE/ESE	CE/ESE	CE/ESE	CE/ESE	CE/ESE	CE/ESE	CE/ESE
2		Elective Course-III	CH																			
	SOECH757 0	Advanced Chemical Process Intensification	CH	45	0	30	0	0	15	0	30	120	4	30 50	0	30 50	0	0	20 00	0	20 00	100 100
	SOECH758 0	Advanced Separation Processes	CH	45	0	30	0	0	15	0	30	120	4	30 50	0	30 50	0	0	20 00	0	20 00	100 100
	SOECH759 0	Reaction Engineering and Reactor Design	CH	45	0	30	0	0	15	0	30	120	4	30 50	0	30 50	0	0	20 00	0	20 00	100 100
		Elective Course-IV	CH																			
	SOECH760 0	Process Dynamics and Advanced Control	CH	45	0	30	0	0	15	0	30	120	4	30 50	0	30 50	0	0	20 00	0	20 00	100 100
	SOECH761 0	Soft Materials and Nanotechnology	CH	45	0	30	0	0	15	0	30	120	4	30 50	0	30 50	0	0	20 00	0	20 00	100 100
	SOECH762 0	Advanced Characterization of Polymeric Materials	CH	45	0	30	0	0	15	0	30	120	4	30 50	0	30 50	0	0	20 00	0	20 00	100 100
Total												**720**	**24**									**1000**

P P Savani University
School of Engineering
Offered by: Department of Chemical Engineering

COURSE DETAILS:

Course Code	SOECH7010
Course Name	Research Methodology and Ethics
Prerequisite Course/s	None

TEACHING SCHEME:

Credit	Total Learning Hours	Direct Contact Hours			Indirect Contact Hours				
		Theory	Practical	Tutorial	Project	CS	Assignment	Term Work	Self-Learning
4	120	45	0	30	0	0	30	0	15

GD = Group Discussion | CS = Case Study | FV = Field Visit | PPT = Presentation

EXAMINATION SCHEME:

Theory		Practical		Tutorial		Project		CS		Assignment		Term Work		Self-Learning		Total
CE	ESE	CE	ESE	CE	ESE	CE	ESE	CE	ESE	CE	ESE	CE	ESE	CE	ESE	
30	50	0	0	30	50	0	0	0	0	20	0	0	0	20	0	200

CE: Continuous Evaluation, ESE: End Semester Exam

OBJECTIVE OF THE COURSE:

To help learners to:

- TDevelop a strong foundation in mathematical modeling techniques that enable students to represent, analyze, and solve complex engineering and research problems using analytical and computational approaches.
- Equip students with advanced numerical methods for solving algebraic, differential, and partial differential equations that arise in real-world engineering systems and simulations.
- Enable the application of optimization techniques and data-driven modeling for research-based decision-making and process/system performance improvement in diverse engineering domains.
- Familiarize students with modern computational tools and software such as MATLAB, Python, Aspen Plus, and scientific libraries for effective simulation, analysis, and visualization of mathematical models.
- Enhance students' ability to apply statistical, probabilistic, and data analysis techniques for experimental data interpretation, hypothesis testing, and uncertainty quantification in engineering research.

COURSE CONTENT:

Module No.	Content	Hours	Weightage in%
1	**Introduction to Research and Research Process:** Meaning and objectives of research; Types of research – Fundamental, Applied, Exploratory, and Empirical; Research process and research problem formulation; Criteria for good research.	05	10

2	**Literature Review, Research Ethics and Methodology:** Sources of literature and techniques for literature review; Use of databases and citation indexing (Scopus, Web of Science, Google Scholar); Research ethics and ethical codes; Plagiarism and detection tools (Turnitin, Grammarly, etc.); Research design types – Descriptive, Analytical, Experimental; Sampling techniques and hypothesis formulation; Measurement scales and data collection methods; Case studies and surveys in research.	12	25
3	**Data Analysis and Interpretation:** Statistical analysis of data (mean, median, mode, standard deviation, etc.); Hypothesis testing, confidence intervals, and p-values; Correlation and regression analysis; Data visualization and interpretation using software tools (Excel, SPSS, R, Python).	05	15
4	**Technical Writing and Research Documentation:** Structure and formatting of research papers, theses, and dissertations; Referencing styles (IEEE, APA, MLA); Writing abstracts, technical reports, and conference papers; Use of LaTeX, MS Word, and reference management tools (Mendeley, Zotero).	05	10
5	**Intellectual Property Rights and Patent System:** Overview of Intellectual Property Rights (IPR); Types of IPR – Patents, Copyrights, Trademarks, Industrial Designs, Trade Secrets; Importance of IPR in research and innovation; Indian and international patent systems (WIPO, PCT); Patent drafting, claims, specifications, and filing procedures in India and abroad; Patent search databases (Espacenet, USPTO, InPASS); Technology transfer and commercialization of IPR.	13	25
6	**Case Studies and Contemporary Issues in IPR:** Case studies of patent infringement and IP litigation; IPR in academia-industry collaborations; Startups and IP strategies; Emerging trends in IPR – Artificial Intelligence and IP, Open Innovation, Creative Commons.	05	15
	TOTAL	**45**	**100%**

LIST OF PRACTICAL / TUTORIAL:

Sr. No	Practical / Tutorial	Hours
1	Overview of research meaning, objectives, types (fundamental, applied, exploratory, empirical); research process.	02
2	Steps in research problem formulation; criteria for good research.	02
3	Sources of literature; techniques for literature review using databases (Scopus, Web of Science, Google Scholar).	02
4	Research ethics, ethical codes, plagiarism, tools (Turnitin, Grammarly).	02
5	Research design types (descriptive, analytical, experimental); sampling techniques.	02
6	Hypothesis formulation; measurement scales and data collection methods.	02
7	Statistical measures (mean, median, mode, standard deviation); hypothesis testing.	02
8	Correlation, regression, confidence intervals, p-values; visualization using Excel, SPSS, R, Python.	02

9	Structure and formatting of research papers, theses; referencing styles (IEEE, APA, MLA).	02
10	Writing abstracts, technical reports, conference papers; LaTeX, Mendeley, Zotero.	02
11	Overview of IPR (patents, copyrights, trademarks, designs, trade secrets); importance in research.	02
12	Indian and international patent systems (WIPO, PCT); patent filing basics.	02
13	Patent drafting, claims, specifications; filing procedures; databases (Espacenet, USPTO, InPASS).	02
14	Technology transfer; commercialization of IPR.	02
15	Patent infringement, IP litigation, academia-industry collaborations, startups, AI and IP, Open Innovation, Creative Commons.	02
	TOTAL	**30**

SELF-LEARNING ONLINE RESOURCES:

Sr. No	Link / Description	Self-Learning Hours
1	https://youtu.be/TEqYnV6KWfY?si=UzuKsaX_3VgvnzWf ; https://youtu.be/mAVswCbz_jM?si=CztpFDdGGhyUW2NX ; https://youtu.be/IZLn9_PA_4s?si=Ek9cgAi-S05WPGh6 ; Introduction to Research and Research Process	3
2	https://www.youtube.com/live/91Em1nze7K8?si=kFbWSBChEPkJPoAV ; https://youtu.be/TMQwDQ6eMXc?si=91NKmB5qmtSRoNWn ; https://youtu.be/NxE4xqHk218?si=Ico2bFLGx1hfPjPj ; Literature Review, Research Ethics and Methodology	3
3	https://youtu.be/K9teElePNkk?si=4hh3jbzvn1sdzd2m ; https://youtu.be/XZo4xyJXCak?si=e2gMdqhN29nhcx0w ; https://www.youtube.com/live/cezxxA7YA1g?si=m3d5Whhuz3ZSeSXt ; Data Analysis and Interpretation	3
4	https://youtu.be/vT5pcc30Ffw?si=2mz5nBppVC1pG5M1 ; https://youtu.be/NM53k7x_jjk?si=8BXymJU-xBXHyemM ; https://youtu.be/76ikqUXByrw?si=UWk7SbtnZxBN2kAm ; Technical Writing and Research Documentation	2
5	https://www.youtube.com/live/Zf9NGO7qQhQ?si=hhVpU8e5TTKnm4EN ; https://youtu.be/6wW2dVrbx6s?si=rjeezftR9YdZJyGi ; https://www.youtube.com/live/VutajIhMMcc?si=0DvPuDEVsHB0tDij ; Intellectual Property Rights and Patent System	2
6	https://youtu.be/PoAEZ1_GwZY?si=F99VgpJ9hpwtgcny ; https://youtu.be/8sP3kBs7Ppg?si=RDlpb4RfyHW_EvhV ; https://youtu.be/Kv2FnR1-it4?si=mqly56GJGs2ailBc ; Case Studies and Contemporary Issues in IPR	2

COURSE EVALUATION & ASSESSMENT RUBRICS:

Component	CE/ESE	Evaluation Methodology / Rubrics	Marks	Passing Marks
Theory	CE	Two Internal Tests of 30 marks each shall be conducted during the semester. The average of both tests will be converted to 30 marks.	30	00

	ESE	Comprehensive written examination covering all modules of the course. Duration: 2 Hours	50	25
Tutorial	CE	Performance of case studies which should be evaluated out of 10 marks for each practical and average of the same will be converted to 30 marks.	30	00
	ESE	Quiz / Tutorial Performance – 25Marks External Viva Voce – 25 Marks	50	25
Assignment	CE	Assignment Evaluation Rubrics Understanding & Coverage of Content– 5 Marks Analysis, Critical Thinking & Evidence– 5 Marks Structure, Flow & Organization– 5 Marks Grammar, Style & Formatting/Referencing– 5 Marks	20	00
Self Learning	CE	40 MCQ questions based on self-study resources and online learning | 0.5 marks per question | Total = 20 marks	20	00
		TOTAL MARKS	**200**	**50**

TEXT BOOK(S):

Title	Author/s	Publication
Research Methodology: Methods and Techniques	C. R. Kothari, Gaurav Garg	New Age International Publishers (2019)

REFERENCE BOOK(S):

Title	Author/s	Publication
Research Methodology: A Step-by-Step Guide for Beginners	Ranjit Kumar	SAGE Publications (2018)
Intellectual Property Rights: Unleashing the Knowledge Economy	Prabuddha Ganguli	Tata McGraw-Hill (2001)

COURSE OUTCOME(S):

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

SOECH7010	Research Methodology and Ethics
CO 1	Identify appropriate research problems and design suitable methodologies for academic and industrial research.
CO 2	Conduct comprehensive literature reviews using standard databases and apply ethical practices in research and writing.
CO 3	Analyze, interpret, and validate experimental data using statistical tools and visualization techniques.
CO 4	Prepare well-structured research documents and understand the publication process and citation ethics
CO 5	Explain the fundamentals of Intellectual Property Rights and apply patent search, drafting, and filing concepts for protecting and commercializing research outcomes.

MAPPING OF CO WITH PO:

SOECH7010	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	2	-	2	-	-	-	-	-	-	-
CO 2	2	3	-	3	2	-	-	-	-	-	-

CO 3	2	3	3	3	3	-	-	-	-	-	-
CO 4	1	2	3	2	2	-	-	-	-	2	-
CO 5	-	-	-	-	-	-	-	3	3	3	2

MAPPING OF CO WITH PSO:

SOECH7010	PSO1	PSO2	PSO3
CO 1	2	2	1
CO 2	3	2	2
CO 3	3	3	2
CO 4	2	3	2
CO 5	1	2	3

LEVEL OF REVISED BLOOM'S TAXONOMY IN ASSESSMENT

1: Remember	2: Understand	3: Apply
4: Analyze	5: Evaluate	6: Create

Module No	**Content**	**RBT Level**
1	Introduction to Research and Research Process	1,2
2	Literature Review, Research Ethics and Methodology	3
3	Data Analysis and Interpretation	3
4	Technical Writing and Research Documentation	5
5	Intellectual Property Rights and Patent System	4
6	Case Studies and Contemporary Issues in IPR	6

P P Savani University
School of Engineering
Offered by: Department of Chemical Engineering

COURSE DETAILS:

Course Code	SOECH7810
Course Name	Research Project-I
Prerequisite Course/s	None

TEACHING SCHEME:

Credit	Total Learning Hours	Direct Contact Hours			Indirect Contact Hours				
		Theory	Practical	Tutorial	Project	PPT	Assignment	Term Work	Self-Learning
12	360	0	0		240	60	0	0	60

GD = Group Discussion | CS = Case Study | FV = Field Visit | PPT = Presentation

EXAMINATION SCHEME:

Theory		Practical		Tutorial		Project		PPT		Assignment		Term Work		Self-Learning		Total
CE	ESE	CE	ESE	CE	ESE	CE	ESE	CE	ESE	CE	ESE	CE	ESE	CE	ESE	
0		0				100	100	00	100	0		0		100	00	200

CE: Continuous Evaluation, ESE: End Semester Exam

OBJECTIVE OF THE COURSE:

To help learners to:

- Identify and formulate a research problem in a chosen domain of engineering and technology.
- Conduct an extensive literature survey using research databases and scholarly resources.
- Develop skills in problem analysis, methodology design, experimentation planning, and result interpretation.
- Enhance technical writing, presentation, and documentation skills.
- Prepare a strong foundation for the successful execution of Research Project.

COURSE CONTENT:

Module No.	Content	Hours	Weightage in%
1	**Project Activities:** Identification of Research Problem and Domain Selection		10
2	**Project Activities:** Literature Review and Research Gap Analysis		10
3	**Project Activities:** Problem Formulation and Objective Definition		10
4	**Project Activities:** Research Methodology Design		15
5	**Project Activities:** Dataset/Experimental Setup Preparation		15
6	**Project Activities:** Initial Design and Prototype Development		10

7	**Project Activities:** Technical Writing		10
8	**Project Activities:** Mid-Term Progress Presentation		10
9	**Project Activities:** Final Presentation		10
	TOTAL	**0**	**100%**

SELF-LEARNING ONLINE RESOURCES:

Sr. No	Link / Description	Self-Learning Hours
1	NPTEL Research Methodology Courses	10
2	IEEE Xplore Digital Library	10
3	SpringerLink	10
4	Scopus & Web of Science	10
5	Elsevier Researcher Academy	10
6	Google Scholar	10

COURSE EVALUATION & ASSESSMENT RUBRICS:

Component	CE/ESE	Evaluation Methodology / Rubrics	Marks	Passing Marks
Project Progress	CE	Literature survey, problem formulation, methodology design, mentor evaluation	100	0
Project Final Evaluation	ESE	Technical contribution, implementation progress, report quality, presentation and viva voce	100	50
PPT Presentation	ESE	Content quality, presentation skills, technical understanding, response to questions	100	50
Self Learning	CE	Research paper reviews, online certifications, technical report submissions	100	0
		TOTAL MARKS	**400**	**100**

COURSE OUTCOME(S):

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

SOECH7810	Research Project-I
CO 1	Identify and define a research problem with reference to current trends in Computer Engineering.
CO 2	Analyze relevant literature and select appropriate tools and techniques.
CO 3	Develop and implement innovative solutions or models for real-world problems.
CO 4	Evaluate research findings and present technical documentation and publications.
CO 5	Demonstrate professional ethics, teamwork, and project management skills throughout the research process.

MAPPING OF CO WITH PO:

SOECH7810	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	2	3	-	2	-	-	-	-	-	-	2

CO 2	2	3	-	2	3	-	-	-	-	-	2
CO 3	3	2	3	-	3	-	-	-	-	-	2
CO 4	-	2	-	3	1	-	-	-	3	-	2
CO 5	-	-	-	-	-	2	3	3	1	3	2

MAPPING OF CO WITH PSO:

SOECH7810	PSO1	PSO2	PSO3
CO 1	3	2	1
CO 2	2	3	1
CO 3	3	3	2
CO 4	2	2	2
CO 5	2	2	3

LEVEL OF REVISED BLOOM'S TAXONOMY IN ASSESSMENT

1: Remember	2: Understand	3: Apply
4: Analyze	5: Evaluate	6: Create

P P Savani University
School of Engineering
Offered by: Department of Chemical Engineering

COURSE DETAILS:

Course Code	SOECH7510
Course Name	Physico-Chemical Techniques for Wastewater Treatment
Prerequisite Course/s	None

TEACHING SCHEME:

Credit	Total Learning Hours	Direct Contact Hours			Indirect Contact Hours				
		Theory	Practical	Tutorial	Project	CS	Assignment	Term Work	Self-Learning
4	120	45	0	30	0	0	15	0	30

GD = Group Discussion | CS = Case Study | FV = Field Visit | PPT = Presentation

EXAMINATION SCHEME:

Theory		Practical		Tutorial		Project		CS		Assignment		Term Work		Self-Learning		Total
CE	ESE	CE	ESE	CE	ESE	CE	ESE	CE	ESE	CE	ESE	CE	ESE	CE	ESE	
30	50	0		30	50	0	0	0	0	20	00	0	0	20	00	200

CE: Continuous Evaluation, ESE: End Semester Exam

OBJECTIVE OF THE COURSE:

To help learners to:

- Understand the sources, characteristics, and pollution impacts of wastewater and the need for physico-chemical treatment methods.
- Apply principles of pre-treatment, primary treatment, sedimentation, filtration, and coagulation–flocculation processes in wastewater management.
- Analyze the performance of advanced physico-chemical treatment technologies such as adsorption, ion exchange, membrane separation, and advanced oxidation processes.
- Evaluate suitable treatment schemes for industrial wastewater based on pollutant characteristics, regulatory requirements, and process economics.
- Develop sustainable wastewater treatment strategies incorporating emerging technologies, water reuse, resource recovery, and zero liquid discharge concepts.

COURSE CONTENT:

Module No.	Content	Hours	Weightage in%
1	**Introduction, Wastewater Characteristics and Pre-Treatment Methods:** Water pollution overview; sources and characteristics of wastewater; point and non-point pollution sources; physical treatment methods; preliminary and pre-treatment units; screening, grit removal, flow equalization; hydraulic and organic load balancing; aeration principles and oxygen transfer mechanisms; coagulation and flocculation processes;	07	15

	coagulants and flocculants; floc formation and removal efficiency.		
2	**Primary Treatment and Filtration Processes:** Principles of primary treatment; sedimentation theory; types of settling (discrete, flocculent, hindered); clarifiers and settling tanks; design parameters including detention time and surface overflow rate; sludge collection and removal; filtration mechanisms; slow and rapid sand filters; filter media characteristics; head loss development; backwashing and filter performance evaluation.	08	18
3	**Physico-Chemical Separation Technologies:** Adsorption principles and isotherms; activated carbon and alternative adsorbents; ion exchange processes and resin regeneration; membrane separation technologies including microfiltration, ultrafiltration, nanofiltration, and reverse osmosis; membrane fouling, cleaning, and operational considerations.	08	18
4	**Advanced Oxidation Processes (AOPs):** Fundamentals of advanced oxidation processes; hydroxyl radical generation and reaction kinetics; chemical oxidation; Fenton and catalytic oxidation processes; degradation mechanisms of organic pollutants; UV-based oxidation systems; UV/H_2O_2 treatment; photocatalysis using semiconductor catalysts; titanium dioxide applications; advantages and limitations of AOP technologies.	07	15
5	**Electrochemical, Sonochemical and Industrial Wastewater Treatment Applications:** Sonochemical treatment and ultrasonic cavitation; electrochemical wastewater treatment; electro-oxidation processes; energy efficiency and process optimization; characteristics of industrial wastewater; treatment of effluents from chemical and allied industries; pollutant identification; treatment train selection; sludge management; performance evaluation and cost analysis.	08	17
6	**Emerging Technologies, Sustainability and Regulatory Framework:** Nanotechnology in wastewater treatment; nano-adsorbents and nano-membranes; hybrid treatment systems; integration of physico-chemical and biological processes; environmental regulations and discharge standards; compliance monitoring; water reuse and recycling; resource recovery; circular economy concepts; zero liquid discharge (ZLD); environmental impact assessment and future trends.	07	17
	TOTAL	**45**	**100%**

LIST OF PRACTICAL / TUTORIAL:

Sr. No	Practical / Tutorial	Hours
1	Identification and classification of wastewater sources; analysis of point vs non-point pollution sources using real-life examples.	02
2	Numerical problems on flow equalization and hydraulic load balancing; discussion on aeration requirements.	02

3	Design-based problems on screening, grit removal, and coagulation–flocculation units.	02
4	Sedimentation theory problems: settling velocity, detention time, and clarifier performance.	02
5	Design of settling tanks and calculation of surface overflow rate with numerical examples.	02
6	Filtration system problems: rapid vs slow sand filters, head loss calculation, and backwashing analysis.	02
7	Adsorption equilibrium problems using Freundlich and Langmuir isotherms.	02
8	Ion exchange resin selection and regeneration calculations for industrial wastewater.	02
9	Comparative analysis of membrane processes (MF, UF, NF, RO) for different wastewater streams.	02
10	Reaction mechanism and numerical problems related to Fenton oxidation and hydroxyl radical generation.	02
11	Case-based discussion on UV/H_2O_2, photocatalysis, and electrochemical AOPs.	02
12	Energy efficiency and process optimization comparison of advanced AOP techniques.	02
13	Industrial wastewater case study: selection of treatment train for chemical/process industries.	02
14	Techno-economic evaluation of emerging technologies including nanotechnology and hybrid systems.	02
15	Regulatory compliance analysis: CPCB norms, ZLD feasibility, and sustainable wastewater management strategies.	02
	TOTAL	**30**

SELF-LEARNING ONLINE RESOURCES:

Sr. No	**Link / Description**	**Self-Learning Hours**
1	https://youtu.be/TEqYnV6KWfY?si=UzuKsaX_3VgvnzWf ; https://youtu.be/mAVswCbz_jM?si=CztpFDdGGhyUW2NX ; https://youtu.be/IZLn9_PA_4s?si=Ek9cgAi-S05WPGh6 ; Introduction, Wastewater Characteristics and Pre-Treatment Methods	5
2	https://www.youtube.com/live/91Em1nze7K8?si=kFbWSBChEPkJPoAV ; https://youtu.be/TMQwDQ6eMXc?si=91NKmB5qmtSRoNWn ; https://youtu.be/NxE4xqHk218?si=Ico2bFLGx1hfPjPj ; Primary Treatment and Filtration Processes	5
3	https://youtu.be/K9teElePNkk?si=4hh3jbzvn1sdzd2m ; https://youtu.be/XZo4xyJXCak?si=e2gMdqhN29nhcx0w ; https://www.youtube.com/live/cezxxA7YA1g?si=m3d5Whhuz3ZSeSXt ; Physico-Chemical Separation Technologies	5
4	https://youtu.be/vT5pcc30Ffw?si=2mz5nBppVC1pG5M1 ; https://youtu.be/NM53k7x_jjk?si=8BXymJU-xBXHyemM ; https://youtu.be/76ikqUXByrw?si=UWk7SbtnZxBN2kAm ; Advanced Oxidation Processes (AOPs)	5
5	https://www.youtube.com/live/Zf9NGO7qQhQ?si=hhVpU8e5TTKnm4EN ; https://youtu.be/6wW2dVrbx6s?si=rjeezftR9YdZJyGi ; https://www.youtube.com/live/VutajIhMMcc?si=0DvPuDEVsHB0tDij ; Electrochemical, Sonochemical and Industrial Wastewater Treatment Applications	5

6	https://youtu.be/PoAEZ1_GwZY?si=F99VgpJ9hpwtgcny ; https://youtu.be/8sP3kBs7Ppg?si=RDlpb4RfyHW_EvhV ; https://youtu.be/Kv2FnR1-it4?si=mqly56GJGs2ailBc ; Emerging Technologies, Sustainability and Regulatory Framework	5

COURSE EVALUATION & ASSESSMENT RUBRICS:

Component	CE/ESE	Evaluation Methodology / Rubrics	Marks	Passing Marks
Theory	CE	Two Internal Tests of 30 marks each shall be conducted during the semester. The average of both tests will be converted to 30 marks.	30	00
	ESE	Comprehensive written examination covering all modules of the course. Duration: 2 Hours	50	25
Tutorial	CE	Performance of case studies which should be evaluated out of 10 marks for each practical and average of the same will be converted to 30 marks.	30	00
	ESE	Quiz / Tutorial Performance – 25Marks External Viva Voce – 25 Marks	50	25
Assignment	CE	Assignment Evaluation Rubrics Understanding & Coverage of Content– 5 Marks Analysis, Critical Thinking & Evidence– 5 Marks Structure, Flow & Organization– 5 Marks • Grammar, Style & Formatting/Referencing– 5 Marks	20	00
Self Learning	CE	40 MCQ questions based on self-study resources and online learning | 0.5 marks per question | Total = 20 marks	20	00
		TOTAL MARKS	**200**	**50**

TEXT BOOK(S):

Title	Author/s	Publication
Wastewater Engineering: Treatment & Reuse	Metcalf & Eddy	McGraw-Hill, 5th Ed.

REFERENCE BOOK(S):

Title	Author/s	Publication
Principles of Water and Wastewater Treatment	Mackenzie Davis	Wiley, (2010)
Advanced Oxidation Processes for Water Treatment	Mihaela I. Stefan	IWA Publishing, (2017)

COURSE OUTCOME(S):

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

SOECH7510	Physico-Chemical Techniques for Wastewater Treatment
CO 1	Explain the principles and applications of coagulation, flocculation, and sedimentation.
CO 2	Analyze and design adsorption, ion exchange, and membrane separation processes.
CO 3	Evaluate the peformance of different treatment units.
CO 4	Select suitable physico-chemical methods based on wastewater characteristics

CO 5	Evaluate regulatory and sustainable approaches for wastewater treatment, including ZLD.

MAPPING OF CO WITH PO:

SOECH7510	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	2	-	2	-	-	-	-	-	-	-
CO 2	2	3	-	3	2	-	-	-	-	-	-
CO 3	2	3	3	3	3	-	-	-	-	-	-
CO 4	1	2	3	2	2	-	-	-	-	2	-
CO 5	-	-	-	-	-	-	-	3	3	3	2

MAPPING OF CO WITH PSO:

SOECH7510	PSO1	PSO2	PSO3
CO 1	2	2	1
CO 2	3	2	2
CO 3	3	3	2
CO 4	2	3	2
CO 5	1	2	3

LEVEL OF REVISED BLOOM'S TAXONOMY IN ASSESSMENT

1: Remember	2: Understand	3: Apply
4: Analyze	5: Evaluate	6: Create

Module No	Content	RBT Level
1	Introduction, Wastewater Characteristics and Pre-Treatment Methods	1,2
2	Primary Treatment and Filtration Processes	3
3	Physico-Chemical Separation Technologies	3
4	Advanced Oxidation Processes (AOPs)	5
5	Electrochemical, Sonochemical and Industrial Wastewater Treatment Applications	4
6	Emerging Technologies, Sustainability and Regulatory Framework	6

P P Savani University

School of Engineering

Offered by: Department of Chemical Engineering

COURSE DETAILS:

Course Code	SOECH7520
Course Name	Environmental Engineering and Pollution Control
Prerequisite Course/s	None

TEACHING SCHEME:

Credit	Total Learning Hours	Direct Contact Hours			Indirect Contact Hours				
		Theory	Practical	Tutorial	Project	CS	Assignment	Term Work	Self-Learning
4	120	45	0	30	0	0	15	0	30

GD = Group Discussion | CS = Case Study | FV = Field Visit | PPT = Presentation

EXAMINATION SCHEME:

Theory		Practical		Tutorial		Project		CS		Assignment		Term Work		Self-Learning		Total
CE	ESE	CE	ESE	CE	ESE	CE	ESE	CE	ESE	CE	ESE	CE	ESE	CE	ESE	
30	50	0	0	30	50	0	0	0	0	20	00	0	0	20	00	200

CE: Continuous Evaluation, ESE: End Semester Exam

OBJECTIVE OF THE COURSE:

To help learners to:

- Understand the sources, characteristics, and environmental impacts of wastewater and the principles of physico-chemical treatment processes.
- Apply fundamental concepts of pre-treatment, sedimentation, coagulation–flocculation, and filtration for wastewater treatment system design and operation.
- Analyze the performance of advanced physico-chemical treatment technologies including adsorption, ion exchange, membrane separation, and advanced oxidation processes.
- Evaluate suitable treatment schemes for industrial wastewater considering pollutant characteristics, treatment efficiency, regulatory standards, and economic feasibility.
- Develop sustainable wastewater management solutions incorporating emerging technologies, water reuse, resource recovery, circular economy principles, and zero liquid discharge concepts.

COURSE CONTENT:

Module No.	Content	Hours	Weightage in%
1	**Wastewater Characteristics and Preliminary Treatment:** Water pollution overview; sources and characteristics of wastewater; point and non-point pollution sources; physical treatment methods; preliminary and pre-treatment units; screening, grit removal, flow equalization; hydraulic and organic load balancing; aeration principles and oxygen transfer mechanisms.	07	15

2	**Coagulation, Flocculation and Primary Treatment Processes:** Principles of coagulation and flocculation; coagulants and flocculants; floc formation and removal efficiency; principles of primary treatment; sedimentation theory; types of settling (discrete, flocculent, hindered); clarifiers and settling tanks; design parameters; sludge collection and removal.	08	18
3	**Filtration and Physico-Chemical Separation Technologies:** Filtration mechanisms; slow and rapid sand filters; filter media characteristics; head loss development; backwashing and filter performance evaluation; adsorption principles and isotherms; activated carbon and alternative adsorbents; ion exchange processes and resin regeneration.	08	18
4	**Membrane Processes and Advanced Oxidation Technologies:** Membrane separation technologies including microfiltration, ultrafiltration, nanofiltration, and reverse osmosis; membrane fouling and cleaning; fundamentals of advanced oxidation processes; hydroxyl radical generation; chemical oxidation; Fenton and catalytic oxidation processes; UV/H_2O_2 treatment and photocatalysis.	07	15
5	**Electrochemical, Sonochemical and Industrial Wastewater Treatment:** Sonochemical treatment and ultrasonic cavitation; electrochemical wastewater treatment; electro-oxidation processes; energy efficiency and process optimization; characteristics of industrial wastewater; treatment of effluents from chemical and allied industries; pollutant identification; treatment train selection; sludge management; performance evaluation and cost analysis.	08	17
6	**Emerging Technologies, Sustainability and Regulatory Framework:** Nanotechnology in wastewater treatment; nano-adsorbents and nano-membranes; hybrid treatment systems; integration of physico-chemical and biological processes; environmental regulations and discharge standards; compliance monitoring; water reuse and recycling; resource recovery; circular economy concepts; zero liquid discharge (ZLD); environmental impact assessment and future trends.	07	17
	TOTAL	**45**	**100%**

LIST OF PRACTICAL / TUTORIAL:

Sr. No	Practical / Tutorial	Hours
1	Identification of environmental compartments (air, water, soil) and classification of pollution sources with real-life examples	2
2	Case-based discussion on bioaccumulation, biomagnification, and food chain contamination	2
3	Numerical and conceptual problems on atmospheric dispersion and human health impacts	2
4	Interpretation of air and water quality standards (NAAQS, CPCB norms) using sample data	2

5	Comparison of emission standards and effluent discharge limits for different industries	2
6	Pollution monitoring methods: selection of sampling techniques for air, water, and solid waste	2
7	Cleaner production and pollution prevention strategies for small and medium industries	2
8	Design-oriented problems on particulate control devices (cyclones, ESPs, bag filters)	2
9	Case study on gaseous pollutant control technologies (scrubbers, SCR, FGD)	2
10	Numerical problems on coagulation, sedimentation, and filtration in water treatment	2
11	Comparative analysis of primary, secondary, and tertiary wastewater treatment systems	2
12	Industry-specific pollution control strategies including ZLD and cleaner technologies	2
13	Solid waste management planning: segregation, composting, landfilling, and WtE options	2
14	Hazardous and special waste management (e-waste, plastic, biomedical waste) with EPR concepts	2
15	Environmental audit and sustainability assessment for an industrial facility	2
	TOTAL	**30**

SELF-LEARNING ONLINE RESOURCES:

Sr. No	Link / Description	Self-Learning Hours
1	https://youtu.be/TEqYnV6KWfY?si=UzuKsaX_3VgvnzWf ; https://youtu.be/mAVswCbz_jM?si=CztpFDdGGhyUW2NX ; https://youtu.be/IZLn9_PA_4s?si=Ek9cgAi-S05WPGh6 ; Introduction, Wastewater Characteristics and Pre-Treatment Methods	5
2	https://www.youtube.com/live/91Em1nze7K8?si=kFbWSBChEPkJPoAV ; https://youtu.be/TMQwDQ6eMXc?si=91NKmB5qmtSRoNWn ; https://youtu.be/NxE4xqHk218?si=Ico2bFLGx1hfPjPj ; Primary Treatment and Filtration Processes	5
3	https://youtu.be/K9teElePNkk?si=4hh3jbzvn1sdzd2m ; https://youtu.be/XZo4xyJXCak?si=e2gMdqhN29nhcx0w ; https://www.youtube.com/live/cezxxA7YA1g?si=m3d5Whhuz3ZSeSXt ; Physico-Chemical Separation Technologies	5
4	https://youtu.be/vT5pcc30Ffw?si=2mz5nBppVC1pG5M1 ; https://youtu.be/NM53k7x_jjk?si=8BXymJU-xBXHyemM ; https://youtu.be/76ikqUXByrw?si=UWk7SbtnZxBN2kAm ; Advanced Oxidation Processes (AOPs)	5
5	https://www.youtube.com/live/Zf9NGO7qQhQ?si=hhVpU8e5TTKnm4EN ; https://youtu.be/6wW2dVrbx6s?si=rjeezftR9YdZJyGi ; https://www.youtube.com/live/VutajIhMMcc?si=0DvPuDEVsHB0tDij ; Electrochemical, Sonochemical and Industrial Wastewater Treatment	5

	Applications	
6	https://youtu.be/PoAEZ1_GwZY?si=F99VgpJ9hpwtgcny ; https://youtu.be/8sP3kBs7Ppg?si=RDlpb4RfyHW_EvhV ; https://youtu.be/Kv2FnR1-it4?si=mqly56GJGs2ailBc ; Emerging Technologies, Sustainability and Regulatory Framework	5

COURSE EVALUATION & ASSESSMENT RUBRICS:

Component	CE/ESE	Evaluation Methodology / Rubrics	Marks	Passing Marks
Theory	CE	Two Internal Tests of 30 marks each shall be conducted during the semester. The average of both tests will be converted to 30 marks.	30	00
	ESE	Comprehensive written examination covering all modules of the course. Duration: 2 Hours	50	25
Tutorial	CE	Performance of case studies which should be evaluated out of 10 marks for each practical and average of the same will be converted to 30 marks.	30	00
	ESE	Quiz / Tutorial Performance – 25Marks External Viva Voce – 25 Marks	50	25
Assignment	CE	Assignment Evaluation Rubrics Understanding & Coverage of Content– 5 Marks Analysis, Critical Thinking & Evidence– 5 Marks Structure, Flow & Organization– 5 Marks • Grammar, Style & Formatting/Referencing– 5 Marks	20	00
Self Learning	CE	40 MCQ questions based on self-study resources and online learning | 0.5 marks per question | Total = 20 marks	20	00
		TOTAL MARKS	**200**	**50**

TEXT BOOK(S):

Title	Author/s	Publication
Environmental Pollution Control Engineering	C.S. Rao	New Age International

REFERENCE BOOK(S):

Title	Author/s	Publication
Wastewater Engineering	Metcalf & Eddy	McGraw-Hill
Air Pollution Control	Cooper & Alley	Waveland Press

COURSE OUTCOME(S):

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

SOECH7520	Environmental Engineering and Pollution Control
CO 1	Identify major environmental pollutants and their sources.

CO 2	Explain environmental impacts and control measures.
CO 3	Apply basic treatment principles for pollution abatement.
CO 4	Demonstrate knowledge of environmental regulations and standards.
CO 5	Evaluate sustainable and regulatory approaches for environmental pollution abatement.

MAPPING OF CO WITH PO:

SOECH7520	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	2	-	2	-	-	-	-	-	-	-
CO 2	2	3		3	2	-	-	-	-	-	-
CO 3	2	3	3	3	3	-	-	-	-	-	-
CO 4	1	2	3	2	2	-	-	-		2	-
CO 5	-	-	-	-	-	-	-	3	3	3	2

MAPPING OF CO WITH PSO:

SOECH7520	PSO1	PSO2	PSO3
CO 1	2	2	1
CO 2	3	2	2
CO 3	3	3	2
CO 4	2	3	2
CO 5	1	2	3

LEVEL OF REVISED BLOOM'S TAXONOMY IN ASSESSMENT

1: Remember	2: Understand	3: Apply
4: Analyze	5: Evaluate	6: Create

Module No	Content	RBT Level
1	Introduction, Wastewater Characteristics and Pre-Treatment Methods	1,2
2	Primary Treatment and Filtration Processes	3
3	Physico-Chemical Separation Technologies	3
4	Advanced Oxidation Processes (AOPs)	5
5	Electrochemical, Sonochemical and Industrial Wastewater Treatment Applications	4
6	Emerging Technologies, Sustainability and Regulatory Framework	6

P P Savani University

School of Engineering

Offered by: Department of Chemical Engineering

COURSE DETAILS:

Course Code	SOECH7530
Course Name	Environmental Monitoring, Quality Assessment & Analysis
Prerequisite Course/s	None

TEACHING SCHEME:

Credit	Total Learning Hours	Direct Contact Hours			Indirect Contact Hours				
		Theory	Practical	Tutorial	Project	CS	Assignment	Term Work	Self-Learning
4	120	45	0	30	0	0	15	0	30

GD = Group Discussion | CS = Case Study | FV = Field Visit | PPT = Presentation

EXAMINATION SCHEME:

Theory		Practical		Tutorial		Project		CS		Assignment		Term Work		Self-Learning		Total
CE	ESE	CE	ESE	CE	ESE	CE	ESE	CE	ESE	CE	ESE	CE	ESE	CE	ESE	
30	50	0	0	30	50	0	0	0	0	20	00	0	0	20	00	200

CE: Continuous Evaluation, ESE: End Semester Exam

OBJECTIVE OF THE COURSE:

To help learners to:

- Understand the principles of environmental fate, transport, toxicology, and risk assessment of pollutants in various environmental compartments.
- Analyze the physicochemical properties of environmental contaminants and their distribution, persistence, bioaccumulation, and partitioning behavior in air, water, soil, and sediment.
- Develop proficiency in environmental monitoring, sampling strategies, quality assurance/quality control (QA/QC), and analytical techniques used for environmental assessment.
- Apply environmental fate and transport models, including mass balance and atmospheric dispersion models, to predict contaminant movement and exposure pathways.
- Evaluate integrated environmental transport scenarios and interpret monitoring and modeling results for environmental management, regulatory compliance, and decision-making.

COURSE CONTENT:

Module No.	Content	Hours	Weightage in%
1	**Fundamentals of Environmental Fate, Toxicology and Risk Assessment:** Definition and components of the environment; environmental compartments (air, water, soil, sediment); source–environment–receptor linkage; pollutant release pathways; exposure routes and exposure assessment; acute and chronic exposure; health effects of contaminants; fundamentals of toxicology; dose–response relationships; threshold and non-	07	15

	threshold effects; environmental risk concepts and risk perception.		
2	**Chemicals of Environmental Concern and Equilibrium Partitioning:** Classification of environmental contaminants; physicochemical properties affecting environmental behavior; solubility, vapor pressure, Henry's law constant; organic carbon partition coefficient (Koc); octanol–water partition coefficient (Kow); persistence, biodegradation, bioaccumulation; equilibrium partitioning theory; phase distribution among environmental media; implications for environmental exposure and transport.	08	18
3	**Environmental Monitoring, Sampling and Analytical Methods:** Environmental monitoring objectives; screening parameters for water quality; BOD, COD, TOC, TDS; monitoring strategies; sampling locations and frequency; QA/QC procedures; data reliability and error analysis; principles of environmental sampling; air, water, soil and sediment sampling techniques; grab and composite sampling; sample preservation, storage and preparation; analytical methods for organic and inorganic contaminants; instrumental techniques; detection limits and analytical interferences.	08	18
4	**Environmental Fate and Transport Modeling Fundamentals:** Need for environmental modeling; mass balance approach; BOX models; steady-state and dynamic models; multimedia transport concepts; environmental compartment interactions; model assumptions and limitations; role of modeling in prediction, exposure assessment, and environmental management.	08	17
5	**Atmospheric Dispersion and Environmental Mass Transport Processes:** Atmospheric transport mechanisms; advection and diffusion; Gaussian plume and puff models; source characterization; meteorological influences; intraphase mass transport; interphase mass transfer; air–water and air–solid interfaces; diffusion and convection coefficients; boundary layer concepts.	07	15
6	**Chemical Exchange Mechanisms and Integrated Environmental Modeling:** Air–water exchange; volatilization and absorption; sediment–water interactions; deposition and resuspension; soil–air exchange and vapor intrusion; factors influencing exchange rates; integrated multimedia transport models; coupling of air, water, and soil systems; uncertainty and sensitivity analysis; industrial and urban contamination case studies; regulatory applications and decision-making.	07	17
	TOTAL	**45**	**100%**

LIST OF PRACTICAL / TUTORIAL:

Sr. No	Practical / Tutorial	Hours

1	Introduction to Environmental Compartments and Pollutant Pathways.	2
2	Source–Environment–Receptor Linkage and Exposure Assessment Problems.	2
3	Toxicity, Dose–Response Relationships, and Risk Interpretation.	2
4	Physicochemical Properties of Pollutants (Kow, Koc, Henry's Law) – Numerical Problems.	2
5	Equilibrium Partitioning Calculations Across Air–Water–Soil Systems.	2
6	Water Quality Parameters (BOD, COD, TOC, TDS) – Data Interpretation.	2
7	Design of Environmental Monitoring Programs and Sampling Frequency.	2
8	QA/QC in Environmental Monitoring and Error Analysis.	2
9	Sampling Techniques for Air, Water, and Soil – Case-Based Discussion.	2
10	Analytical Techniques for Organic and Inorganic Pollutants.	2
11	Introduction to Mass Balance and Box Models – Problem Solving.	2
12	Atmospheric Dispersion Modeling (Gaussian Plume) – Numerical Examples.	2
13	Interphase Mass Transfer and Chemical Exchange Mechanisms.	2
14	Integrated Environmental Transport Models – Case Study Analysis.	2
15	Regulatory Compliance, Reporting, and Environmental Case Studies.	2
	TOTAL	**30**

SELF-LEARNING ONLINE RESOURCES:

Sr. No	**Link / Description**	**Self-Learning Hours**
1	https://youtu.be/TEqYnV6KWfY?si=UzuKsaX_3VgvnzWf ; https://youtu.be/mAVswCbz_jM?si=CztpFDdGGhyUW2NX ; https://youtu.be/IZLn9_PA_4s?si=Ek9cgAi-S05WPGh6 ; Fundamentals of Environmental Fate, Toxicology and Risk Assessment	5
2	https://www.youtube.com/live/91Em1nze7K8?si=kFbWSBChEPkJPoAV ; https://youtu.be/TMQwDQ6eMXc?si=91NKmB5qmtSRoNWn ; https://youtu.be/NxE4xqHk218?si=Ico2bFLGx1hfPjPj ; Chemicals of Environmental Concern and Equilibrium Partitioning	5
3	https://youtu.be/K9teElePNkk?si=4hh3jbzvn1sdzd2m ; https://youtu.be/XZo4xyJXCak?si=e2gMdqhN29nhcx0w ; https://www.youtube.com/live/cezxxA7YA1g?si=m3d5Whhuz3ZSeSXt ; Environmental Monitoring, Sampling and Analytical Methods	5
4	https://youtu.be/vT5pcc30Ffw?si=2mz5nBppVC1pG5M1 ; https://youtu.be/NM53k7x_jjk?si=8BXymJU-xBXHyemM ; https://youtu.be/76ikqUXByrw?si=UWk7SbtnZxBN2kAm ; Environmental Fate and Transport Modeling Fundamentals	5
5	https://www.youtube.com/live/Zf9NGO7qQhQ?si=hhVpU8e5TTKnm4EN ; https://youtu.be/6wW2dVrbx6s?si=rjeezftR9YdZJyGi ; https://www.youtube.com/live/VutajIhMMcc?si=0DvPuDEVsHB0tDij ; Atmospheric Dispersion and Environmental Mass Transport Processes	5
6	https://youtu.be/PoAEZ1_GwZY?si=F99VgpJ9hpwtgcny ; https://youtu.be/8sP3kBs7Ppg?si=RDlpb4RfyHW_EvhV ; https://youtu.be/Kv2FnR1-it4?si=mqly56GJGs2ailBc ; Chemical Exchange Mechanisms and Integrated Environmental Modeling	5

COURSE EVALUATION & ASSESSMENT RUBRICS:

Component	**CE/ESE**	**Evaluation Methodology / Rubrics**	**Marks**	**Passing Marks**

Theory	CE	Two Internal Tests of 30 marks each shall be conducted during the semester. The average of both tests will be converted to 30 marks.	30	00
	ESE	Comprehensive written examination covering all modules of the course. Duration: 2 Hours	50	25
Tutorial	CE	Performance of case studies which should be evaluated out of 10 marks for each practical and average of the same will be converted to 30 marks.	30	00
	ESE	Quiz / Tutorial Performance – 25Marks External Viva Voce – 25 Marks	50	25
Assignment	CE	Assignment Evaluation Rubrics Understanding & Coverage of Content– 5 Marks Analysis, Critical Thinking & Evidence– 5 Marks Structure, Flow & Organization– 5 Marks • Grammar, Style & Formatting/Referencing– 5 Marks	20	00
Self Learning	CE	40 MCQ questions based on self-study resources and online learning | 0.5 marks per question | Total = 20 marks	20	00
		TOTAL MARKS	**200**	**50**

TEXT BOOK(S):

Title	Author/s	Publication
Environmental Fate and Transport Analysis	John Smith & Jane Trump	ABC Publishers, (2020)

REFERENCE BOOK(S):

Title	Author/s	Publication
Principles of Environmental Chemistry	William Brown	WILEY Publishers, (2020)
Chemical Fate and Transport in the Environment	Mark Davis	WILEY Publishers, (2020)

COURSE OUTCOME(S):

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

SOECH7530	Environmental Monitoring, Quality Assessment & Analysis
CO 1	Perform appropriate sampling for environmental media.
CO 2	Use laboratory instruments and techniques for pollutant analysis.
CO 3	Interpret and analyze environmental data.
CO 4	Prepare technical reports in compliance with regulatory norms.
CO 5	Analyze pollutant fate and transport using environmental modeling approaches.

MAPPING OF CO WITH PO:

SOECH7530	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	2	-	2	-	-	-	-	-	-	-
CO 2	2	3		3	2	-	-	-	-	-	-

CO 3	2	3	3	3	3	-	-	-	-	-	-
CO 4	1	2	3	2	2	-	-	-	-	2	-
CO 5	-	-	-	-	-	-	-	3	3	3	2

MAPPING OF CO WITH PSO:

SOECH7530	PSO1	PSO2	PSO3
CO 1	2	2	1
CO 2	3	2	2
CO 3	3	3	2
CO 4	2	3	2
CO 5	1	2	3

LEVEL OF REVISED BLOOM'S TAXONOMY IN ASSESSMENT

1: Remember	2: Understand	3: Apply
4: Analyze	5: Evaluate	6: Create

Module No	Content	RBT Level
1	Fundamentals of Environmental Fate, Toxicology and Risk Assessment	1,2
2	Chemicals of Environmental Concern and Equilibrium Partitioning	3
3	Environmental Monitoring, Sampling and Analytical Methods	3
4	Environmental Fate and Transport Modeling Fundamentals	5
5	Atmospheric Dispersion and Environmental Mass Transport Processes	4
6	Chemical Exchange Mechanisms and Integrated Environmental Modeling	6

P P Savani University

School of Engineering

Offered by: Department of Chemical Engineering

COURSE DETAILS:

Course Code	SOECH7540
Course Name	Applied Environmental Engineering
Prerequisite Course/s	None

TEACHING SCHEME:

Credit	Total Learning Hours	Direct Contact Hours			Indirect Contact Hours				
		Theory	Practical	Tutorial	Project	CS	Assignment	Term Work	Self-Learning
4	120	45	0	30	0	0	15	0	30

GD = Group Discussion | CS = Case Study | FV = Field Visit | PPT = Presentation

EXAMINATION SCHEME:

Theory		Practical		Tutorial		Project		CS		Assignment		Term Work		Self-Learning		Total
CE	ESE	CE	ESE	CE	ESE	CE	ESE	CE	ESE	CE	ESE	CE	ESE	CE	ESE	
30	50	00	00	30	50	0	00	00	00	20	00	00	00	20	00	200

CE: Continuous Evaluation, ESE: End Semester Exam

OBJECTIVE OF THE COURSE:

To help learners to:

- Understand the sources, characteristics, impacts, and regulatory aspects of environmental pollution in industrial and municipal systems.
- Apply pollution prevention and cleaner production strategies for resource conservation, waste minimization, and sustainable industrial operations.
- Analyze and design air pollution control systems for the removal of particulate and gaseous pollutants from industrial emissions.
- Evaluate physical, biological, and solid waste treatment technologies for effective environmental management and compliance.
- Assess emerging pollution control technologies, environmental auditing procedures, and regulatory compliance requirements for sustainable development.

COURSE CONTENT:

Module No.	Content	Hours	Weightage in%
1	**Fundamentals of Environmental Pollution and Regulations:** Concept and definition of environment; types and sources of industrial pollution; air, water, noise, and solid waste pollution; emission and effluent characterization; physical, chemical, and biological properties of industrial wastes; environmental quality parameters; environmental laws,	07	15

	standards, and regulatory bodies; importance of pollution control in sustainable industrial development.		
2	**Pollution Prevention and Cleaner Production:** Principles of pollution prevention; cleaner production concepts; process modification techniques; raw material substitution; waste reduction at source; waste recovery and recycling; material and energy balance applications; water minimization; leak detection and control; process integration; economic and environmental benefits of pollution prevention.	08	18
3	**Air Pollution Control Engineering:** Fundamentals of air pollution control; particulate matter characteristics; cyclone separators; electrostatic precipitators; wet and dry scrubbers; gaseous pollutant control; absorption and adsorption processes; equipment design considerations; efficiency evaluation; pressure drop; energy requirements; industrial applications.	08	18
4	**Water and Wastewater Treatment Technologies:** Sources and characteristics of water pollution; screening, grit removal, sedimentation, filtration, centrifugation, coagulation and flocculation; principles of biological treatment; aerobic and anaerobic processes; activated sludge process; trickling filters; aeration systems; sludge handling and treatment efficiency evaluation.	07	15
5	**Solid Waste Management and Resource Recovery:** Types and characteristics of municipal and industrial solid waste; collection, segregation, and transportation; composting; sanitary landfill design; leachate control; incineration; gasification; energy recovery systems; briquetting technology; environmental impacts and sustainable waste management practices.	08	17
6	**Emerging Technologies, Environmental Compliance and Case Studies:** Advanced oxidation processes; zero liquid discharge (ZLD) systems; concentrate management; circular economy principles; industrial symbiosis; resource efficiency; future trends in pollution control engineering; industry case studies; CPCB guidelines; environmental auditing; compliance monitoring and reporting; environmental management systems.	07	17
	TOTAL	**45**	**100%**

LIST OF PRACTICAL / TUTORIAL:

Sr. No	Practical / Tutorial	Hours
1	Overview of Environmental Pollution: Types, Sources, and Industrial Waste Characteristics	02
2	Environmental Quality Parameters and Regulatory Standards (Air, Water, Noise)	02
3	Pollution Prevention and Cleaner Production – Conceptual Problems	02
4	Material and Energy Balance Applications in Pollution Prevention	02
5	Design and Performance Evaluation of Cyclones and ESPs	02
6	Scrubbers and Gas Absorption Systems – Numerical Problems	02
7	Physical Water Treatment Units: Sedimentation and Filtration Design	02

8	Coagulation and Flocculation – Jar Test Analysis and Case Studies	02
9	Biological Treatment Systems: Activated Sludge and Trickling Filters	02
10	Aeration Systems and Oxygen Transfer Calculations	02
11	Solid Waste Characterization and Collection System Planning	02
12	Sanitary Landfill Design, Leachate Control, and Energy Recovery	02
13	Emerging Technologies: AOPs, ZLD, and Circular Economy Concepts	02
14	Industrial Pollution Control Case Studies and CPCB Compliance	02
15	Environmental Auditing, Monitoring, and Sustainability Assessment	02
	TOTAL	**30**

SELF-LEARNING ONLINE RESOURCES:

Sr. No	Link / Description	Self-Learning Hours
1	https://youtu.be/TEqYnV6KWfY?si=UzuKsaX_3VgvnzWf ; https://youtu.be/mAVswCbz_jM?si=CztpFDdGGhyUW2NX ; https://youtu.be/IZLn9_PA_4s?si=Ek9cgAi-S05WPGh6 ; Fundamentals of Environmental Pollution and Regulations	5
2	https://www.youtube.com/live/91Em1nze7K8?si=kFbWSBChEPkJPoAV https://youtu.be/TMQwDQ6eMXc?si=91NKmB5qmtSRoNWn ; https://youtu.be/NxE4xqHk218?si=Ico2bFLGx1hfPjPj ; Pollution Prevention and Cleaner Production	5
3	https://youtu.be/K9teElePNkk?si=4hh3jbzvn1sdzd2m ; https://youtu.be/XZo4xyJXCak?si=e2gMdqhN29nhcx0w ; https://www.youtube.com/live/cezxxA7YA1g?si=m3d5Whhuz3ZSeSXt ; Air Pollution Control Engineering	5
4	https://youtu.be/vT5pcc30Ffw?si=2mz5nBppVC1pG5M1 ; https://youtu.be/NM53k7x_jjk?si=8BXymJU-xBXHyemM ; https://youtu.be/76ikqUXByrw?si=UWk7SbtnZxBN2kAm ; Water and Wastewater Treatment Technologies	5
5	https://www.youtube.com/live/Zf9NGO7qQhQ?si=hhVpU8e5TTKnm4EN https://youtu.be/6wW2dVrbx6s?si=rjeezftR9YdZJyGi ; https://www.youtube.com/live/VutajIhMMcc?si=0DvPuDEVsHB0tDij ; Solid Waste Management and Resource Recovery	5
6	https://youtu.be/PoAEZ1_GwZY?si=F99VgpJ9hpwtgcny ; https://youtu.be/8sP3kBs7Ppg?si=RDlpb4RfyHW_EvhV ; https://youtu.be/Kv2FnR1-it4?si=mqly56GJGs2ailBc ; Emerging Technologies, Environmental Compliance and Case Studies	5

COURSE EVALUATION & ASSESSMENT RUBRICS:

Component	CE/ESE	Evaluation Methodology / Rubrics	Marks	Passing Marks
Theory	CE	Two Internal Tests of 30 marks each shall be conducted during the semester. The average of both tests will be converted to 30 marks.	30	00
	ESE	Comprehensive written examination covering all modules of the course. Duration: 2 Hours	50	25
Tutorial	CE	Performance of case studies which should be evaluated out of 10 marks for each practical and average of the same will be converted to 30 marks.	30	00

	ESE	Quiz / Tutorial Performance – 25Marks External Viva Voce – 25 Marks	50	25
Assignment	CE	Assignment Evaluation Rubrics Understanding & Coverage of Content– 5 Marks Analysis, Critical Thinking & Evidence– 5 Marks Structure, Flow & Organization– 5 Marks • Grammar, Style & Formatting/Referencing– 5 Marks	20	00
Self Learning	CE	40 MCQ questions based on self-study resources and online learning | 0.5 marks per question | Total = 20 marks	20	00
		TOTAL MARKS	**200**	**50**

TEXT BOOK(S):

Title	Author/s	Publication
Industrial Water Pollution Control	W.W. Eckenfelder	McGraw-Hill, 2nd Ed.

REFERENCE BOOK(S):

Title	Author/s	Publication
Wastewater Engineering: Treatment & Reuse	Tchobanoglous et al.	McGraw-Hill, 4th Ed.
Handbook of Solid Waste Management	Kreith & Tchobanoglous	McGraw-Hill, 2nd Ed.

COURSE OUTCOME(S):

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

SOECH7540	Applied Environmental Engineering
CO 1	Design and analyze water and wastewater treatment processes.
CO 2	Understand the principles of solid waste and air pollution control.
CO 3	Apply engineering solutions to environmental problems.
CO 4	Integrate environmental and sustainability principles in engineering design.
CO 5	Apply principles of cleaner production, circular economy, and sustainability to design and evaluate pollution control and environmental management systems.

MAPPING OF CO WITH PO:

SOECH7540	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	2	-	2	-	-	-	-	-	-	-
CO 2	2	3	-	3	2	-	-	-	-	-	-
CO 3	2	3	3	3	3	-	-	-	-	-	-
CO 4	1	2	3	2	2	-	-	-	-	2	-
CO 5	-	-	-	-	-	-	-	3	3	3	2

MAPPING OF CO WITH PSO:

SOECH7540	PSO1	PSO2	PSO3
CO 1	2	2	1
CO 2	3	2	2
CO 3	3	3	2

CO 4	2	3	2
CO 5	1	2	3

LEVEL OF REVISED BLOOM'S TAXONOMY IN ASSESSMENT

1: Remember	2: Understand	3: Apply
4: Analyze	5: Evaluate	6: Create

Module No	Content	RBT Level
1	Fundamentals of Environmental Pollution and Regulations	1,2
2	Pollution Prevention and Cleaner Production	3
3	Air Pollution Control Engineering	3
4	Water and Wastewater Treatment Technologies	5
5	Solid Waste Management and Resource Recovery	4
6	Emerging Technologies, Environmental Compliance and Case Studies	6

P P Savani University

School of Engineering

Offered by: Department of Chemical Engineering

COURSE DETAILS:

Course Code	SOECH7550
Course Name	Fuel Science and Combustion Technology
Prerequisite Course/s	None

TEACHING SCHEME:

Credit	Total Learning Hours	Direct Contact Hours			Indirect Contact Hours				
		Theory	Practical	Tutorial	Project	CS	Assignment	Term Work	Self-Learning
4	120	45	0	30	0	0	15	0	30

GD = Group Discussion | CS = Case Study | FV = Field Visit | PPT = Presentation

EXAMINATION SCHEME:

Theory		Practical		Tutorial		Project		CS		Assignment		Term Work		Self-Learning		Total
CE	ESE	CE	ESE	CE	ESE	CE	ESE	CE	ESE	CE	ESE	CE	ESE	CE	ESE	
30	50	0	0	30	50	0	0	0	0	20	00	0	0	20	00	200

CE: Continuous Evaluation, ESE: End Semester Exam

OBJECTIVE OF THE COURSE:

To help learners to:

- Understand the origin, classification, properties, and characterization techniques of solid, liquid, and gaseous fuels.
- Analyze the production, processing, utilization, and performance of fossil and alternative fuels used in industrial applications.
- Apply thermochemical principles and combustion stoichiometry for fuel evaluation and combustion system design.
- Evaluate combustion mechanisms, flame characteristics, and factors influencing combustion efficiency and stability.
- Assess combustion equipment, pollutant formation mechanisms, and emission control strategies for sustainable energy utilization.

COURSE CONTENT:

Module No.	Content	Hours	Weightage in%
1	**Introduction to Fuels and Fuel Characterization:** Historical development and origin of fuels; classification of fuels; renewable and non-renewable fuels; global and national fuel scenario; fuel consumption patterns; physical and chemical properties of fuels; proximate and ultimate analysis; calorific value; ignition temperature; ash and moisture content; measurement and evaluation of fuel properties.	07	15
2	**Solid and Liquid Fossil Fuels:**	08	18

	Coal formation, classification, rank and grade; coal mining methods; coal preparation and beneficiation; coke production; coal liquefaction and gasification; Fischer–Tropsch synthesis; origin and composition of petroleum; crude oil characterization; petroleum exploration and drilling; atmospheric and vacuum distillation; refinery flow schemes; cracking, reforming, alkylation, isomerization, and product blending.		
3	**Gaseous Fuels and Fuel Processing Technologies:** Types and properties of gaseous fuels; natural gas production and processing; LPG; producer gas and water gas; hydrogen production technologies; acetylene generation; calorific value determination; storage, transportation, advantages, limitations, and industrial applications of gaseous fuels.	08	17
4	**Thermochemistry and Combustion Calculations:** Thermochemical equations; heat of reaction and combustion; Hess's law; enthalpy changes; higher and lower calorific values; bond energy concepts; stoichiometric combustion; theoretical and excess air requirements; flue gas analysis; adiabatic flame temperature; combustion efficiency; mass and energy balance calculations for combustion systems.	08	18
5	**Combustion Mechanisms and Flame Phenomena:** Combustion kinetics; reaction mechanisms; chain reactions; ignition and ignition delay; flammability limits; explosion phenomena; premixed and diffusion flames; flame structure; factors affecting combustion rate, stability, and efficiency.	07	15
6	**Combustion Appliances, Emissions and Control:** Industrial burners and furnaces; furnace design principles; heat transfer in furnaces; internal combustion engines; spark ignition and compression ignition engines; efficiency improvement techniques; formation of combustion pollutants (CO, NOx, SOx, particulate matter); emission control technologies and environmental aspects of fuel combustion.	07	17
	TOTAL	**45**	**100%**

LIST OF PRACTICAL / TUTORIAL:

Sr. No	Practical / Tutorial	Hours
1	Classification of Fuels and Comparative Analysis of Fuel Properties	02
2	Proximate and Ultimate Analysis – Numerical Problems	02
3	Coal Rank, Grade, and Beneficiation Techniques – Case Discussion	02
4	Coke Making and Coal Conversion Processes (Liquefaction & Gasification)	02
5	Environmental Impacts of Coal Utilization and Mitigation Strategies	02
6	Petroleum Crude Characterization and Refinery Flow Diagram Analysis	02
7	Distillation and Secondary Processing Units – Problem Solving	02
8	Gaseous Fuels Properties, Storage, and Safety Aspects	02
9	Thermochemical Equations and Heat of Combustion Calculations	02
10	Higher and Lower Calorific Value Determination – Numerical Problems	02
11	Stoichiometric Combustion and Theoretical Air Requirement	02
12	Excess Air, Flue Gas Analysis, and Adiabatic Flame Temperature	02
13	Combustion Mechanisms, Flame Types, and Ignition Phenomena	02
14	Design and Performance of Industrial Burners and Furnaces	02

15	Emission Formation, Combustion Efficiency, and Cleaner Fuel Options	02
	TOTAL	**30**

SELF-LEARNING ONLINE RESOURCES:

Sr. No	Link / Description	Self-Learning Hours
1	https://youtu.be/TEqYnV6KWfY?si=UzuKsaX_3VgvnzWf ; https://youtu.be/mAVswCbz_jM?si=CztpFDdGGhyUW2NX ; https://youtu.be/IZLn9_PA_4s?si=Ek9cgAi-S05WPGh6 ; Introduction to Fuels and Fuel Characterization	5
2	https://www.youtube.com/live/91Em1nze7K8?si=kFbWSBChEPkJPoAV ; https://youtu.be/TMQwDQ6eMXc?si=91NKmB5qmtSRoNWn ; https://youtu.be/NxE4xqHk218?si=Ico2bFLGx1hfPjPj ; Solid and Liquid Fossil Fuels	5
3	https://youtu.be/K9teElePNkk?si=4hh3jbzvn1sdzd2m ; https://youtu.be/XZo4xyJXCak?si=e2gMdqhN29nhcx0w ; https://www.youtube.com/live/cezxxA7YA1g?si=m3d5Whhuz3ZSeSXt ; Gaseous Fuels and Fuel Processing Technologies	5
4	https://youtu.be/vT5pcc30Ffw?si=2mz5nBppVC1pG5M1 ; https://youtu.be/NM53k7x_jjk?si=8BXymJU-xBXHyemM ; https://youtu.be/76ikqUXByrw?si=UWk7SbtnZxBN2kAm ; Thermochemistry and Combustion Calculations	5
5	https://www.youtube.com/live/Zf9NGO7qQhQ?si=hhVpU8e5TTKnm4EN ; https://youtu.be/6wW2dVrbx6s?si=rjeezftR9YdZJyGi ; https://www.youtube.com/live/VutajIhMMcc?si=0DvPuDEVsHB0tDij ; Combustion Mechanisms and Flame Phenomena	5
6	https://youtu.be/PoAEZ1_GwZY?si=F99VgpJ9hpwtgcny ; https://youtu.be/8sP3kBs7Ppg?si=RDlpb4RfyHW_EvhV ; https://youtu.be/Kv2FnR1-it4?si=mqly56GJGs2ailBc ; Combustion Appliances, Emissions and Control	5

COURSE EVALUATION & ASSESSMENT RUBRICS:

Component	CE/ESE	Evaluation Methodology / Rubrics	Marks	Passing Marks
Theory	CE	Two Internal Tests of 30 marks each shall be conducted during the semester. The average of both tests will be converted to 30 marks.	30	00
	ESE	Comprehensive written examination covering all modules of the course. Duration: 2 Hours	50	25
Tutorial	CE	Performance of case studies which should be evaluated out of 10 marks for each practical and average of the same will be converted to 30 marks.	30	00
	ESE	Quiz / Tutorial Performance – 25Marks External Viva Voce – 25 Marks	50	25
Assignment	CE	Assignment Evaluation Rubrics Understanding & Coverage of Content– 5 Marks Analysis, Critical Thinking & Evidence– 5 Marks Structure, Flow & Organization– 5 Marks	20	00

		• Grammar, Style & Formatting/Referencing–5 Marks		
Self Learning	CE	40 MCQ questions based on self-study resources and online learning | 0.5 marks per question | Total = 20 marks	20	00
		TOTAL MARKS	**200**	**50**

TEXT BOOK(S):

Title	Author/s	Publication
Fuels and Combustion	Samir Sarkar	Universities Press, 3rd Edition

REFERENCE BOOK(S):

Title	Author/s	Publication
Petroleum Refinery Engineering	W.L. Nelson	McGraw-Hill
Fuels Combustion and Furnaces	John Griswold	McGraw-Hill

COURSE OUTCOME(S):

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

SOECH7550	Fuel Science and Combustion Technology
CO 1	Classify fuels and analyze their properties.
CO 2	Apply combustion equations and analyze energy efficiency.
CO 3	Design basic combustion systems with emission considerations.
CO 4	Evaluate environmental impacts of fuel usage and suggest alternatives.
CO 5	Evaluate sustainable combustion technologies and cleaner fuel options.

MAPPING OF CO WITH PO:

SOECH7550	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	2	-	2	-	-	-	-	-	-	-
CO 2	2	3		3	2	-	-	-	-	-	-
CO 3	2	3	3	3	3	-	-	-	-	-	-
CO 4	1	2	3	2	2	-	-	-	-	2	-
CO 5	-	-	-	-	-	-	-	3	3	3	2

MAPPING OF CO WITH PSO:

SOECH7550	PSO1	PSO2	PSO3
CO 1	2	2	1
CO 2	3	2	2
CO 3	3	3	2
CO 4	2	3	2
CO 5	1	2	3

LEVEL OF REVISED BLOOM'S TAXONOMY IN ASSESSMENT

1: Remember	2: Understand	3: Apply
4: Analyze	5: Evaluate	6: Create

Module No	Content	RBT Level
1	Introduction to Fuels and Fuel Characterization	1,2
2	Solid and Liquid Fossil Fuels	3
3	Gaseous Fuels and Fuel Processing Technologies	3
4	Thermochemistry and Combustion Calculations	5
5	Combustion Mechanisms and Flame Phenomena	4
6	Combustion Appliances, Emissions and Control	6

P P Savani University
School of Engineering
Offered by: Department of Chemical Engineering

COURSE DETAILS:

Course Code	SOECH7560
Course Name	Optimization Techniques in Chemical Engineering
Prerequisite Course/s	None

TEACHING SCHEME:

Credit	Total Learning Hours	Direct Contact Hours			Indirect Contact Hours				
		Theory	Practical	Tutorial	Project	CS	Assignment	Term Work	Self-Learning
4	120	45	0	30	0	0	15	0	30

GD = Group Discussion | CS = Case Study | FV = Field Visit | PPT = Presentation

EXAMINATION SCHEME:

Theory		Practical		Tutorial		Project		CS		Assignment		Term Work		Self-Learning		Total
CE	ESE	CE	ESE	CE	ESE	CE	ESE	CE	ESE	CE	ESE	CE	ESE	CE	ESE	
30	50	0	0	30	50	0	0	0	0	20	00	0	0	20	00	200

CE: Continuous Evaluation, ESE: End Semester Exam

OBJECTIVE OF THE COURSE:

To help learners to:

- Understand the fundamental principles, classifications, and significance of optimization techniques in chemical engineering applications.
- Formulate optimization problems by defining objective functions, decision variables, and operational constraints for engineering systems.
- Apply unconstrained and constrained optimization methods to solve process design and operational problems.
- Analyze linear, nonlinear, and evolutionary optimization algorithms for engineering decision-making and resource management.
- Utilize modern optimization software and computational tools to solve real-world chemical engineering optimization problems and evaluate optimal solutions.

COURSE CONTENT:

Module No.	Content	Hours	Weightage in%
1	**Fundamentals of Optimization and Problem Formulation:** Introduction to optimization; importance and applications in chemical engineering; classification of optimization problems (linear, nonlinear, integer, mixed-integer, dynamic, deterministic, and stochastic); optimization workflow; decision variables; objective functions; equality and inequality constraints; feasible region; convex and concave sets and	07	15

	functions; optimality concepts; graphical interpretation of optimization problems.		
2	**Unconstrained Optimization Techniques:** Single-variable and multivariable optimization; analytical optimization using derivatives; direct search methods; gradient-based methods; steepest descent method; Newton's method; Nelder–Mead simplex method; convergence behavior; computational considerations and performance evaluation.	08	18
3	**Linear Programming and Constrained Optimization:** Formulation of linear programming problems; standard and canonical forms; graphical solution methods; simplex method; pivot operations; basic and non-basic variables; duality theory; primal-dual relationships; sensitivity analysis; shadow prices; applications in process optimization and resource allocation.	08	18
4	**Nonlinear Programming Methods:** Nonlinear optimization problem formulation; equality and inequality constraints; Lagrange multipliers; Karush–Kuhn–Tucker (KKT) conditions; penalty function methods; barrier methods; quadratic programming; numerical solution techniques; practical implementation issues.	07	15
5	**Optimization Algorithms and Software Tools:** Overview of optimization algorithms; search techniques; gradient-based and second-order methods; evolutionary and nature-inspired algorithms; genetic algorithms; particle swarm optimization; convergence characteristics; stopping criteria; implementation using MATLAB, LINGO, Python solvers (Pyomo); comparison of optimization tools and algorithms.	08	17
6	**Chemical Engineering Applications and Case Studies:** Optimization of reactor design and operation; heat exchanger network optimization; distillation and separation process optimization; process control optimization; production scheduling and planning; resource allocation; economic and environmental optimization; multi-objective optimization; Pareto optimality; industrial case studies; project work and result interpretation.	07	17
	TOTAL	**45**	**100%**

LIST OF PRACTICAL / TUTORIAL:

Sr. No	Practical / Tutorial	Hours
1	Role of Optimization in Chemical Engineering – Industrial Examples and Discussion	02
2	Identification of Decision Variables, Objectives, and Constraints – Practice Problems	02
3	Feasible Region, Convexity, and Graphical Interpretation of Optimization Problems	02
4	Single-Variable Unconstrained Optimization – Analytical Techniques	02
5	Multivariable Optimization Using Gradient and Hessian Concepts	02
6	Numerical Methods for Unconstrained Optimization (Steepest Descent, Newton's Method)	02
7	Formulation of Linear Programming Problems in Chemical Processes	02

8	Graphical Solution of Linear Programming Problems	02
9	Simplex Method – Step-by-Step Numerical Problems	02
10	Duality and Sensitivity Analysis in Linear Programming	02
11	Constrained Nonlinear Optimization Using Lagrange Multipliers	02
12	Karush–Kuhn–Tucker (KKT) Conditions and Quadratic Programming	02
13	Introduction to Optimization Software Tools (MATLAB / LINGO / Python–Pyomo)	02
14	Optimization Applications in Reactor, Separation, and Utility Systems	02
15	Case Study on Multi-Objective Optimization and Trade-Off Analysis	02
	TOTAL	**30**

SELF-LEARNING ONLINE RESOURCES:

Sr. No	Link / Description	Self-Learning Hours
1	https://youtu.be/TEqYnV6KWfY?si=UzuKsaX_3VgvnzWf ; https://youtu.be/mAVswCbz_jM?si=CztpFDdGGhyUW2NX ; https://youtu.be/IZLn9_PA_4s?si=Ek9cgAi-S05WPGh6 ; Fundamentals of Optimization and Problem Formulation	5
2	https://www.youtube.com/live/91Em1nze7K8?si=kFbWSBChEPkJPoAV ; https://youtu.be/TMQwDQ6eMXc?si=91NKmB5qmtSRoNWn ; https://youtu.be/NxE4xqHk218?si=Ico2bFLGx1hfPjPj ; Unconstrained Optimization Techniques	5
3	https://youtu.be/K9teElePNkk?si=4hh3jbzvn1sdzd2m ; https://youtu.be/XZo4xyJXCak?si=e2gMdqhN29nhcx0w ; https://www.youtube.com/live/cezxxA7YA1g?si=m3d5Whhuz3ZSeSXt ; Linear Programming and Constrained Optimization	5
4	https://youtu.be/vT5pcc30Ffw?si=2mz5nBppVC1pG5M1 ; https://youtu.be/NM53k7x_jjk?si=8BXymJU-xBXHyemM ; https://youtu.be/76ikqUXByrw?si=UWk7SbtnZxBN2kAm ; Nonlinear Programming Methods	5
5	https://www.youtube.com/live/Zf9NGO7qQhQ?si=hhVpU8e5TTKnm4EN ; https://youtu.be/6wW2dVrbx6s?si=rjeezftR9YdZJyGi ; https://www.youtube.com/live/VutajIhMMcc?si=0DvPuDEVsHB0tDij ; Optimization Algorithms and Software Tools	5
6	https://youtu.be/PoAEZ1_GwZY?si=F99VgpJ9hpwtgcny ; https://youtu.be/8sP3kBs7Ppg?si=RDlpb4RfyHW_EvhV ; https://youtu.be/Kv2FnR1-it4?si=mqly56GJGs2ailBc ; Chemical Engineering Applications and Case Studies	5

COURSE EVALUATION & ASSESSMENT RUBRICS:

Component	CE/ESE	Evaluation Methodology / Rubrics	Marks	Passing Marks
Theory	CE	Two Internal Tests of 30 marks each shall be conducted during the semester. The average of both tests will be converted to 30 marks.	30	00
	ESE	Comprehensive written examination covering all modules of the course. Duration: 2 Hours	50	25

Tutorial	CE	Performance of case studies which should be evaluated out of 10 marks for each practical and average of the same will be converted to 30 marks.	30	00
	ESE	Quiz / Tutorial Performance – 25Marks External Viva Voce – 25 Marks	50	25
Assignment	CE	Assignment Evaluation Rubrics Understanding & Coverage of Content– 5 Marks Analysis, Critical Thinking & Evidence– 5 Marks Structure, Flow & Organization– 5 Marks • Grammar, Style & Formatting/Referencing– 5 Marks	20	00
Self Learning	CE	40 MCQ questions based on self-study resources and online learning | 0.5 marks per question | Total = 20 marks	20	00
		TOTAL MARKS	**200**	**50**

TEXT BOOK(S):

Title	Author/s	Publication
Introduction to Linear Optimization	Bertsimas and Tsitsiklis	Athena Scientific

REFERENCE BOOK(S):

Title	Author/s	Publication
Nonlinear Programming	Dimitri P. Bertsekas	Athena Scientific
Engineering Optimization	R. T. Haese, Kalyanmoy Deb	Wiley / PHI

COURSE OUTCOME(S):

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

SOECH7560	Optimization Techniques in Chemical Engineering
CO 1	Formulate and solve linear and nonlinear optimization problems.
CO 2	Apply optimization in reactor, separation, and utility systems.
CO 3	Interpret optimization results for process improvement.
CO 4	Use numerical and software tools for decision-making in engineering design.
CO 5	Assess and compare optimization techniques for chemical engineering applications.

MAPPING OF CO WITH PO:

SOECH7560	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	2	-	2	-	-	-	-	-	-	-
CO 2	2	3	-	3	2	-	-	-	-	-	-
CO 3	2	3	3	3	3	-	-	-	-	-	-
CO 4	1	2	3	2	2	-	-	-	-	2	-
CO 5	-	-	-	-	-	-	-	3	3	3	2

MAPPING OF CO WITH PSO:

SOECH7560	PSO1	PSO2	PSO3
CO 1	2	2	1
CO 2	3	2	2

CO 3	3	3	2
CO 4	2	3	2
CO 5	1	2	3

LEVEL OF REVISED BLOOM'S TAXONOMY IN ASSESSMENT

1: Remember	2: Understand	3: Apply
4: Analyze	5: Evaluate	6: Create

Module No	Content	RBT Level
1	Fundamentals of Optimization and Problem Formulation	1,2
2	Unconstrained Optimization Techniques	3
3	Linear Programming and Constrained Optimization	3
4	Nonlinear Programming Methods	5
5	Optimization Algorithms and Software Tools	4
6	Chemical Engineering Applications and Case Studies	6

P P Savani University
School of Engineering
Offered by: Department of Computer Engineering

COURSE DETAILS:

Course Code	SOECE7010
Course Name	Computational Research Techniques
Prerequisite Course/s	None

TEACHING SCHEME:

Credit	Total Learning Hours	Direct Contact Hours			Indirect Contact Hours				
		Theory	Practical	Tutorial	Project	CS	Assignment	Term Work	Self-Learning
4	120	45	0	30	0	0	30	0	15

GD = Group Discussion | CS = Case Study | FV = Field Visit | PPT = Presentation

EXAMINATION SCHEME:

Theory		Practical		Tutorial		Project		CS		Assignment		Term Work		Self-Learning		Total
CE	ESE	CE	ESE	CE	ESE	CE	ESE	CE	ESE	CE	ESE	CE	ESE	CE	ESE	
30	50	0	0	30	50	0	0	0	0	20	00	0	0	20	00	200

CE: Continuous Evaluation, ESE: End Semester Exam

OBJECTIVE OF THE COURSE:

To help learners to:

- Develop a strong foundation in mathematical modeling techniques that enable students to represent, analyze, and solve complex engineering and research problems using analytical and computational approaches.
- Equip students with advanced numerical methods for solving algebraic, differential, and partial differential equations that arise in real-world engineering systems and simulations.
- Enable the application of optimization techniques and data-driven modeling for research-based decision-making and process/system performance improvement in diverse engineering domains.
- Familiarize students with modern computational tools and software such as MATLAB, Python, Aspen Plus, and scientific libraries for effective simulation, analysis, and visualization of mathematical models.
- Enhance students' ability to apply statistical, probabilistic, and data analysis techniques for experimental data interpretation, hypothesis testing, and uncertainty quantification in engineering research.

COURSE CONTENT:

Module No.	Content	Hours	Weightage in%
1	**Foundations of Mathematical Modeling and Linear Algebra for Research:** Fundamentals of model formulation and validation; Classification of models: deterministic vs. stochastic, static vs. dynamic; Dimensional analysis and similarity; Vector spaces,	08	20

	inner product spaces, Gram-Schmidt orthogonalization; Eigenvalue problems and diagonalization; Applications in chemical process design, Principal Component Analysis (PCA), process control, machine learning, and computational algorithms.		
2	**Differential Equations and Dynamic System Modeling:** Higher-order ordinary differential equations (ODEs) and systems of ODEs; Stability analysis and phase portraits; Laplace transforms and their applications; Introduction to partial differential equations (PDEs): Heat, wave, and Laplace equations; Applications in reaction kinetics, control theory, dynamic system modeling, and transport phenomena.	08	20
3	**Numerical Methods and Scientific Computing:** Numerical differentiation and integration (Trapezoidal and Simpson's rules); Root-finding methods: Newton-Raphson, Secant, and Broyden's methods; Interpolation and curve fitting; Numerical solutions of large systems using Jacobi and Gauss-Seidel methods; Software implementation using MATLAB, Python, and Octave.	07	15
4	**Numerical Solutions of PDEs and Computational Techniques:** Separation of variables; Fourier methods; Finite Difference Method (FDM); Introduction and comparison of Finite Volume Method (FVM) and Finite Element Method (FEM); Applications in Computational Fluid Dynamics (CFD), mass transfer, heat transfer, and neural PDE solvers.	07	15
5	**Optimization Techniques and Data-Driven Modeling:** Classical and non-classical optimization techniques; Linear, nonlinear, constrained, and unconstrained optimization; Metaheuristic algorithms: Genetic Algorithms (GA), Particle Swarm Optimization (PSO), and Simulated Annealing; Probability distributions and random variables; Regression modeling and data-driven model development; Applications in process design and machine learning.	08	20
6	**Statistical Analysis, Computational Tools, and Research Applications:** Estimation, hypothesis testing, confidence intervals, ANOVA, and Bayesian inference; Research-centric use of MATLAB, Python (NumPy, SciPy, SymPy, Pandas, Scikit-learn), Aspen Plus, ANSYS Fluent, TensorFlow, and PyTorch; Error analysis, reproducibility, and scientific documentation; Capstone Project: Solving a real-life or simulated research problem.	07	10
	TOTAL	**45**	**100%**

LIST OF PRACTICAL / TUTORIAL:

Sr. No	Practical / Tutorial	Hours
1	Fundamentals of model formulation and validation; classification of models (deterministic vs. stochastic, static vs. dynamic)	02
2	Dimensional analysis, similarity; applications in chemical process design and computational algorithms	02
3	Vector spaces, inner product spaces, Gram-Schmidt orthogonalization	02

4	Eigenvalue problems, diagonalization, Jordan forms; applications in PCA and process control	02
5	Higher-order ODEs, systems of ODEs; stability analysis and phase portraits	02
6	Laplace transforms; applications in reaction kinetics and control theory	02
7	Heat, wave, and Laplace equations; method of separation of variables	02
8	Fourier, finite difference, FVM, FEM methods; applications in mass transfer and CFD	02
9	Numerical differentiation, integration (Trapezoidal, Simpson's rule); root-finding (Newton-Raphson, Secant)	02
10	Interpolation, curve fitting; implementation in MATLAB, Python, Octave	02
11	Classical and non-classical optimization; linear and non-linear optimization	02
12	Metaheuristic algorithms (Genetic Algorithms, PSO, Simulated Annealing); multivariable optimization	02
13	Probability distributions, random variables; estimation, hypothesis testing	02
14	Regression modeling, ANOVA, Bayesian inference; applications in process monitoring	02
15	MATLAB, Python (NumPy, SciPy, Pandas, Scikit-learn), Aspen Plus, ANSYS Fluent; capstone project	02
	TOTAL	**30**

SELF-LEARNING ONLINE RESOURCES:

Sr. No	Link / Description	Self-Learning Hours
1	https://youtu.be/sKVFkVoYfbs?si=tX5NIrhCmhwY0lKb ; https://youtu.be/FME9avU3u2Y?si=Rrws3iLURl0vyyNj ; https://youtu.be/Pcp7gxAKLTk?si=djZ-nX4h-LSaDyj8 ; Foundations of Mathematical Modeling and Linear Algebra for Research	3
2	https://youtu.be/04pdHAgV38E?si=d-NJZxIig8B2jpsY ; https://youtu.be/u14ZObiV7GU?si=CUwLn290rjBKKkmH ; https://youtu.be/3E8QcXEBvYU?si=xhi0BqaR2VosI1_X ; Differential Equations and Dynamic System Modeling	3
3	https://youtu.be/vg8BtY1lUFE?si=VQiU-zWk_Ykpo9z3 ; https://youtu.be/z2QpdRGYXQk?si=rAU4M2C1ig8liOik ; https://youtu.be/dHvUk7af2H4?si=jDaQq68ac309aYId ; Numerical Methods and Scientific Computing	3
4	https://youtu.be/ZSNl5crAvsw?si=ztaFCWjfF3lxFl1g ; https://youtu.be/svtuoyi3DNw?si=DKuXEZrpy0-fiqsx ; https://youtu.be/QndgX29Ui-M?si=lJYHBfL3mj4pFIAd ; Numerical Solutions of PDEs and Computational Techniques	2
5	https://youtu.be/p_O6SXFGDrA?si=o9BTsSaTPXqXS3q_ ; https://youtu.be/CzgU4BYPYQQ?si=JGBOXBC3TZxZjiDx ; https://youtu.be/COJYh1qBCdo?si=f-Y2GF81W4dIljQ6 ; Optimization Techniques and Data-Driven Modeling	2
6	https://www.youtube.com/live/E0_TPwnWJy0?si=YKK3JJiu5yTw0kSd ; https://youtu.be/zaT4gZa-46U?si=S-1HY9Tbht0YHVFU ; https://youtu.be/ONR_Qxwbyd4?si=kX1Ix-OQWEeOYgOQ ; Statistical Analysis, Computational Tools, and Research Applications	2

COURSE EVALUATION & ASSESSMENT RUBRICS:

Component	CE/ESE	Evaluation Methodology / Rubrics	Marks	Passing Marks
Theory	CE	Two Internal Tests of 30 marks each shall be conducted during the semester. The average of both tests will be converted to 30 marks.	30	00
	ESE	Comprehensive written examination covering all modules of the course. Duration: 2 Hours	50	25
Tutorial	CE	Performance of case studies which should be evaluated out of 10 marks for each practical and average of the same will be converted to 30 marks.	30	00
	ESE	Quiz / Tutorial Performance – 25Marks External Viva Voce – 25 Marks	50	25
Assignment	CE	Assignment Evaluation Rubrics • Technical Depth & Literature Integration – 5 Marks • Methodological Rigor, Analysis & Innovation– 5 Marks • Synthesis, Discussion & Conclusion – 5 Marks • Professional Presentation, LaTeX/Formatting & Citations – 5 Marks	20	00
Self Learning	CE	40 MCQ questions based on self-study resources and online learning | 0.5 marks per question | Total = 20 marks	20	00
		TOTAL MARKS	**200**	**50**

TEXT BOOK(S):

Title	Author/s	Publication
Numerical Methods for Engineers	Steven C. Chapra, Raymond P. Canale	McGraw Hill Education

REFERENCE BOOK(S):

Title	Author/s	Publication
Applied Numerical Methods with MATLAB for Engineers and Scientists	Steven C. Chapra	McGraw Hill Education
Introduction to Statistical Learning	Gareth James, Daniela Witten, Trevor Hastie, Robert Tibshirani	Springer

COURSE OUTCOME(S):

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

SOECE7010	Computational Research Techniques
CO 1	Apply advanced mathematical modeling techniques to represent and analyze complex research problems in various engineering domains.

CO 2	Implement and evaluate various numerical methods for solving linear and nonlinear equations, differential equations, and optimization problems using appropriate computational tools.
CO 3	Analyze and interpret experimental or simulated data using statistical and probabilistic methods for informed decision-making in research applications.
CO 4	Develop and validate research-oriented computational models using modern software platforms and communicate findings effectively.
CO 5	Integrate interdisciplinary approaches, ethical practices, and sustainability principles in developing innovative mathematical and computational research solutions.

MAPPING OF CO WITH PO:

SOECE7010	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	3	-	3	-	-	-	-	-	-	2
CO 2	3	3	-	2	3	-	-	-	-	-	2
CO 3	3	3	-	3	2	-	-	-	-	-	2
CO 4	2	2	-	2	3	-	-	-	3	-	2
CO 5	2	-	2	-	-	3	3	2	-	2	2

MAPPING OF CO WITH PSO:

SOECE7010	PSO1	PSO2	PSO3
CO 1	3	2	2
CO 2	3	3	2
CO 3	2	3	2
CO 4	3	3	2
CO 5	2	3	3

LEVEL OF REVISED BLOOM'S TAXONOMY IN ASSESSMENT

1: Remember	2: Understand	3: Apply
4: Analyze	5: Evaluate	6: Create

Module No	**Content**	**RBT Level**
1	Foundations of Mathematical Modeling and Linear Algebra for Research	1,2
2	Differential Equations and Dynamic System Modeling	3
3	Numerical Methods and Scientific Computing	3
4	Numerical Solutions of PDEs and Computational Techniques	5
5	Optimization Techniques and Data-Driven Modeling	4
6	Statistical Analysis, Computational Tools, and Research Applications	6

P P Savani University
School of Engineering
Offered by: Department of Chemical Engineering

COURSE DETAILS:

Course Code	SOECH7820
Course Name	Research Project-II
Prerequisite Course/s	None

TEACHING SCHEME:

Credit	Total Learning Hours	Direct Contact Hours			Indirect Contact Hours				
		Theory	Practical	Tutorial	Project	PPT	Assignment	Term Work	Self-Learning
12	360	0	0	0	240	60	0	0	60

GD = Group Discussion | CS = Case Study | FV = Field Visit | PPT = Presentation

EXAMINATION SCHEME:

Theory		Practical		Tutorial		Project		PPT		Assignment		Term Work		Self-Learning		Total
CE	ESE	CE	ESE	CE	ESE	CE	ESE	CE	ESE	CE	ESE	CE	ESE	CE	ESE	
0	0	0	0	0	0	100	100	00	100	0	0	0	0	100	0	400

CE: Continuous Evaluation, ESE: End Semester Exam

OBJECTIVE OF THE COURSE:

To help learners to:

- Identify and formulate a research problem in a chosen domain of engineering and technology.
- Conduct an extensive literature survey using research databases and scholarly resources.
- Develop skills in problem analysis, methodology design, experimentation planning, and result interpretation.
- Enhance technical writing, presentation, and documentation skills.
- Prepare a strong foundation for the successful execution of Research Project.

COURSE CONTENT:

Module No.	Content	Hours	Weightage in%
1	**Project Activities:** Identification of Research Problem and Domain Selection		10
2	**Project Activities:** Literature Review and Research Gap Analysis		10
3	**Project Activities:** Problem Formulation and Objective Definition		10
4	**Project Activities:** Research Methodology Design		15
5	**Project Activities:** Dataset/Experimental Setup Preparation		15
6	**Project Activities:** Initial Design and Prototype Development		10

7	**Project Activities:** Technical Writing		10
8	**Project Activities:** Mid-Term Progress Presentation		10
9	**Project Activities:** Final Presentation		10
	TOTAL	**0**	**100%**

SELF-LEARNING ONLINE RESOURCES:

Sr. No	Link / Description	Self-Learning Hours
1	NPTEL Research Methodology Courses	10
2	IEEE Xplore Digital Library	10
3	SpringerLink	10
4	Scopus & Web of Science	10
5	Elsevier Researcher Academy	10
6	Google Scholar	10

COURSE EVALUATION & ASSESSMENT RUBRICS:

Component	CE/ESE	Evaluation Methodology / Rubrics	Marks	Passing Marks
Project Progress	CE	Literature survey, problem formulation, methodology design, mentor evaluation	100	0
Project Final Evaluation	ESE	Technical contribution, implementation progress, report quality, presentation and viva voce	100	50
PPT Presentation	ESE	Content quality, presentation skills, technical understanding, response to questions	100	50
Self Learning	CE	Research paper reviews, online certifications, technical report submissions	100	0
		TOTAL MARKS	**400**	**100**

COURSE OUTCOME(S):

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

SOECH7820	Research Project-II
CO 1	Identify and define a research problem with reference to current trends in Computer Engineering.
CO 2	Analyze relevant literature and select appropriate tools and techniques.
CO 3	Develop and implement innovative solutions or models for real-world problems.
CO 4	Evaluate research findings and present technical documentation and publications.
CO 5	Demonstrate professional ethics, teamwork, and project management skills throughout the research process.

MAPPING OF CO WITH PO:

SOECH7820	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11

CO 1	2	3	-	2	-	-	-	-	-	-	2
CO 2	2	3	-	2	3	-	-	-	-	-	2
CO 3	3	2	3	-	3	-	-	-	-	-	2
CO 4	-	2	-	3	1	-	-	-	3	-	2
CO 5	-	-	-	-	-	2	3	3	1	3	2

MAPPING OF CO WITH PSO:

SOECH7820	PSO1	PSO2	PSO3
CO 1	3	2	1
CO 2	2	3	1
CO 3	3	3	2
CO 4	2	2	2
CO 5	2	2	3

LEVEL OF REVISED BLOOM'S TAXONOMY IN ASSESSMENT

1: Remember	2: Understand	3: Apply
4: Analyze	5: Evaluate	6: Create

P P Savani University
School of Engineering
Offered by: Department of Chemical Engineering

COURSE DETAILS:

Course Code	SOECH7570
Course Name	Advanced Chemical Process Intensification
Prerequisite Course/s	None

TEACHING SCHEME:

Credit	Total Learning Hours	Direct Contact Hours			Indirect Contact Hours				
		Theory	Practical	Tutorial	Project	CS	Assignment	Term Work	Self-Learning
4	120	45	0	30	0	0	15	0	30

GD = Group Discussion | CS = Case Study | FV = Field Visit | PPT = Presentation

EXAMINATION SCHEME:

Theory		Practical		Tutorial		Project		CS		Assignment		Term Work		Self-Learning		Total
CE	ESE	CE	ESE	CE	ESE	CE	ESE	CE	ESE	CE	ESE	CE	ESE	CE	ESE	
30	50	0	0	30	50	0	0	0	0	20	00	0	0	20	00	200

CE: Continuous Evaluation, ESE: End Semester Exam

OBJECTIVE OF THE COURSE:

To help learners to:

- Understand the principles, philosophy, drivers, and significance of Chemical Process Intensification (CPI) for sustainable and efficient chemical process development.
- Analyze intensified heat and mass transfer equipment, multifunctional reactors, and advanced separation technologies used in modern process industries.
- Apply concepts of miniaturization, micro-process engineering, modularization, and alternative energy sources for process enhancement.
- Evaluate intensified processes using process modelling, simulation tools, sustainability indicators, safety principles, and economic assessment methods.
- Design innovative intensified chemical processes that improve productivity, energy efficiency, environmental performance, and process safety.

COURSE CONTENT:

Module No.	Content	Hours	Weightage in%
1	**Fundamentals of Chemical Process Intensification:** Introduction to CPI; definition, philosophy and evolution of process intensification; drivers for intensification; sustainability and green engineering principles; miniaturization and modularization concepts; batch-to-continuous processing; process simplification; transport phenomena enhancement; process intensification metrics;	07	15

	atom economy, eco-efficiency, scaling laws; industrial need and future trends in CPI.		
2	**Intensified Heat and Mass Transfer Systems:** Heat and mass transfer enhancement principles; microchannel and compact heat exchangers; enhanced boiling and condensation systems; rotating packed beds; high-gravity contactors; static mixers and vortex devices; intensified evaporators and crystallizers; membrane-assisted operations; transport enhancement mechanisms; design considerations and industrial applications.	08	18
3	**Novel Reactors and Hybrid Separation Technologies:** Multifunctional reactors; reactive distillation and reactive absorption; membrane reactors; microreactors; oscillatory baffled reactors; spinning disk reactors; catalyst-coated microchannels; plasma, microwave, ultrasound and photocatalytic reactors; hybrid separations including pervaporation, pressure swing distillation, adsorption–membrane systems, SMB chromatography, and electrochemical separations.	08	18
4	**Micro-Systems, Modular Plants and Energy-Based Intensification:** Microfluidics and microreactors; lab-on-chip systems; micro heat exchangers; surface-dominated transport phenomena; microfabrication techniques; modular chemical plants; intensified safety in microsystems; microwave-assisted processing; ultrasound-assisted reactions; plasma-assisted technologies; electrochemical intensification; solar and renewable-energy-driven process intensification.	07	15
5	**Safety, Sustainability and Economic Assessment of Intensified Processes:** Intrinsic safety and safety-by-design concepts; hazard identification and minimization; life cycle assessment (LCA); sustainability metrics; carbon footprint reduction; energy audits; waste minimization; environmental impact assessment; techno-economic analysis; capital and operating cost reduction; modular plant economics; cost–benefit analysis of intensified systems.	08	17
6	**Design, Simulation and Industrial Applications of CPI:** Process modelling and simulation using Aspen Plus and CFD; intensified process design methodologies; hybrid flowsheet development; digital twins and process optimization; pilot-scale intensification; industrial case studies involving reactive distillation, rotating packed beds, membrane reactors, and microreactor technologies; future directions and emerging applications of CPI.	07	17
	TOTAL	**45**	**100%**

LIST OF PRACTICAL / TUTORIAL:

Sr. No	Practical / Tutorial	Hours
1	Introduction to CPI philosophy, need, and scope	02
2	Comparison of conventional vs intensified processes	02

3	Case study: Rotating packed beds (design + calculations)	02
4	Microreactor design calculations and mixing characteristics	02
5	Hybrid reactive–separation units	02
6	Mass transfer enhancement techniques	02
7	Heat transfer intensification in compact exchangers	02
8	Aspen simulation of reactive distillation	02
9	Membrane reactor modeling (basics)	02
10	Ultrasound and microwave assisted reactors	02
11	Economic evaluation of intensified plant	02
12	Energy analysis using PI metrics	02
13	Sustainability evaluation (LCA case study)	02
14	Industrial case studies: Biodiesel, pharma, fine chemicals	02
15	PI-based mini project presentation (viva)	02
	TOTAL	**30**

SELF-LEARNING ONLINE RESOURCES:

Sr. No	Link / Description	Self-Learning Hours
1	https://youtu.be/TEqYnV6KWfY?si=UzuKsaX_3VgvnzWf ; https://youtu.be/mAVswCbz_jM?si=CztpFDdGGhyUW2NX ; https://youtu.be/IZLn9_PA_4s?si=Ek9cgAi-S05WPGh6 ; Fundamentals of Chemical Process Intensification	5
2	https://www.youtube.com/live/91Em1nze7K8?si=kFbWSBChEPkJPoAV https://youtu.be/TMQwDQ6eMXc?si=91NKmB5qmtSRoNWn ; https://youtu.be/NxE4xqHk218?si=Ico2bFLGx1hfPjPj ; Intensified Heat and Mass Transfer Systems	5
3	https://youtu.be/K9teElePNkk?si=4hh3jbzvn1sdzd2m ; https://youtu.be/XZo4xyJXCak?si=e2gMdqhN29nhcx0w ; https://www.youtube.com/live/cezxxA7YA1g?si=m3d5Whhuz3ZSeSXt ; Novel Reactors and Hybrid Separation Technologies	5
4	https://youtu.be/vT5pcc30Ffw?si=2mz5nBppVC1pG5M1 ; https://youtu.be/NM53k7x_jjk?si=8BXymJU-xBXHyemM ; https://youtu.be/76ikqUXByrw?si=UWk7SbtnZxBN2kAm ; Micro-Systems, Modular Plants and Energy-Based Intensification	5
5	https://www.youtube.com/live/Zf9NGO7qQhQ?si=hhVpU8e5TTKnm4EN https://youtu.be/6wW2dVrbx6s?si=rjeezftR9YdZJyGi ; https://www.youtube.com/live/VutajIhMMcc?si=0DvPuDEVsHB0tDij ; Safety, Sustainability and Economic Assessment of Intensified Processes	5
6	https://youtu.be/PoAEZ1_GwZY?si=F99VgpJ9hpwtgcny ; https://youtu.be/8sP3kBs7Ppg?si=RDlpb4RfyHW_EvhV ; https://youtu.be/Kv2FnR1-it4?si=mqly56GJGs2ailBc ; Design, Simulation and Industrial Applications of CPI	5

COURSE EVALUATION & ASSESSMENT RUBRICS:

Component	CE/ESE	Evaluation Methodology / Rubrics	Marks	Passing Marks
Theory	CE	Two Internal Tests of 30 marks each shall be conducted during the semester. The average of both tests will be converted to 30 marks.	30	00

	ESE	Comprehensive written examination covering all modules of the course. Duration: 2 Hours	50	25
Tutorial	CE	Performance of practical which should be evaluated out of 10 marks for each practical and average of the same will be converted to 30 marks.	30	00
	ESE	Quiz / Practical Performance – 25Marks External Viva Voce – 25 Marks	50	25
Assignment	CE	Assignment Evaluation Rubrics Understanding & Coverage of Content– 5 Marks Analysis, Critical Thinking & Evidence– 5 Marks Structure, Flow & Organization– 5 Marks • Grammar, Style & Formatting/Referencing– 5 Marks	20	00
Self Learning	CE	40 MCQ questions based on self-study resources and online learning | 0.5 marks per question | Total = 20 marks	20	00
		TOTAL MARKS	**200**	**50**

TEXT BOOK(S):

Title	Author/s	Publication
Process Intensification in Chemical Engineering	Andrzej Stankiewicz, Jacob A. Moulijn	Elsevier (2003)

REFERENCE BOOK(S):

Title	Author/s	Publication
Process Intensification: Engineering for Efficiency, Sustainability and Flexibility	David Reay, Colin Ramshaw, Adam Harvey	Butterworth-Heinemann (2013)
Microreactors in Organic Synthesis and Catalysis	Thomas Wirth	Wiley-VCH (2013)

COURSE OUTCOME(S):

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

SOECH7570	Advanced Chemical Process Intensification
CO 1	Explain the fundamentals, philosophy, and need of process intensification in modern chemical industries.
CO 2	Analyze intensified heat/mass transfer equipment, multifunctional reactors, and hybrid separation systems.
CO 3	Design and evaluate microreactors, alternative energy-assisted reactors, and compact unit operations.
CO 4	Assess and optimize intensified processes through modeling, simulation, sustainability, and economic metrics.
CO 5	Apply PI concepts to industrial processes for safer, greener, and cost-effective chemical manufacturing.

MAPPING OF CO WITH PO:

SOECH7570	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	2	-	2	-	-	-	-	-	-	-
CO 2	2	3	-	3	2	-	-	-	-	-	-

CO 3	2	3	3	3	3	-	-	-	-	-	-
CO 4	1	2	3	2	2	-	-	-	-	2	-
CO 5	-	-	-	-	-	-	-	3	3	3	2

MAPPING OF CO WITH PSO:

SOECH7570	PSO1	PSO2	PSO3
CO 1	2	2	1
CO 2	3	2	2
CO 3	3	3	2
CO 4	2	3	2
CO 5	1	2	3

LEVEL OF REVISED BLOOM'S TAXONOMY IN ASSESSMENT

1: Remember	2: Understand	3: Apply
4: Analyze	5: Evaluate	6: Create

Module No	**Content**	**RBT Level**
1	Fundamentals of Chemical Process Intensification	1,2
2	Intensified Heat and Mass Transfer Systems	3
3	Novel Reactors and Hybrid Separation Technologies	3
4	Micro-Systems, Modular Plants and Energy-Based Intensification	5
5	Safety, Sustainability and Economic Assessment of Intensified Processes	4
6	Design, Simulation and Industrial Applications of CPI	6

P P Savani University
School of Engineering
Offered by: Department of Chemical Engineering

COURSE DETAILS:

Course Code	SOECH7580
Course Name	Advanced Separation Processes
Prerequisite Course/s	None

TEACHING SCHEME:

Credit	Total Learning Hours	Direct Contact Hours			Indirect Contact Hours				
		Theory	Practical	Tutorial	Project	CS	Assignment	Term Work	Self-Learning
4	120	45	0	30	0	0	15	0	30

GD = Group Discussion | CS = Case Study | FV = Field Visit | PPT = Presentation

EXAMINATION SCHEME:

Theory		Practical		Tutorial		Project		CS		Assignment		Term Work		Self-Learning		Total
CE	ESE	CE	ESE	CE	ESE	CE	ESE	CE	ESE	CE	ESE	CE	ESE	CE	ESE	
30	50	0	0	30	50	0	0	0	0	20	00	0	0	20	00	200

CE: Continuous Evaluation, ESE: End Semester Exam

OBJECTIVE OF THE COURSE:

To help learners to:

- Understand the fundamentals of modern, emerging, and non-conventional separation technologies employed in chemical, biochemical, pharmaceutical, environmental, and process industries.
- Develop knowledge of mass transfer mechanisms, thermodynamic driving forces, transport phenomena, and selectivity principles governing advanced separation processes.
- Acquire proficiency in membrane-based, adsorptive, ion-exchange, chromatographic, supercritical fluid, and hybrid separation techniques for efficient product purification and recovery.
- Analyze, design, model, simulate, and optimize novel separation units and integrated separation systems using theoretical concepts and computational tools.
- Evaluate the technical, economic, and sustainability aspects of advanced separation technologies and apply them to industrial problems in chemical, petrochemical, pharmaceutical, food processing, biotechnology, and wastewater treatment sectors.

COURSE CONTENT:

Module No.	Content	Hours	Weightage in%
1	**Fundamentals of Novel Separation Processes:** Introduction to conventional and non-conventional separation methods; mass transfer mechanisms; thermodynamic driving forces; diffusivity, permeability, selectivity, partition coefficient; process intensification; sustainability and energy-efficient separations; economics of separation processes; industrial applications and case studies.	07	15

2	**Membrane-Based Separation Processes:** Principles and classification of membranes; microfiltration, ultrafiltration, nanofiltration, reverse osmosis, dialysis, pervaporation, membrane distillation; membrane materials and module configurations; flux and selectivity; concentration polarization; membrane fouling and cleaning strategies; industrial applications.	08	18
3	**Adsorptive, Ion-Exchange and Supercritical Fluid Separations:** Adsorption fundamentals; Langmuir and Freundlich isotherms; breakthrough behavior; fixed-bed adsorption; PSA and TSA systems; activated carbon, zeolites, MOFs; ion-exchange processes and regeneration; supercritical fluid extraction using CO_2; phase behavior, extractor design, fractionation, and industrial applications in food, pharmaceutical, and environmental sectors.	08	18
4	**Chromatographic and Bioseparation Techniques:** Principles of chromatography; gas chromatography, liquid chromatography, ion chromatography, affinity chromatography; retention mechanisms, column efficiency, Van Deemter equation, detector technologies; bioseparations, protein purification, enzyme immobilization, aqueous two-phase systems, affinity-based separations, and magnetic separation techniques.	07	15
5	**Advanced Distillation and Emerging Separation Technologies:** Extractive, azeotropic, reactive, and pressure-swing distillation; molecular sieving and dehydration; dividing-wall columns; electrodialysis, forward osmosis, simulated moving bed (SMB) chromatography, cryogenic separation, freeze concentration, ultrasonic separation, nanotechnology-enabled separations; environmental and industrial applications.	08	17
6	**Process Modeling, Simulation and Optimization of Separation Processes:** Mathematical modeling of membrane, adsorption, chromatography, and hybrid separation systems; mass and energy balance equations; transport and thermodynamic models; process simulation using Aspen Plus, MATLAB, and COMSOL Multiphysics; optimization techniques, design of experiments (DoE), sensitivity analysis, parameter estimation, techno-economic analysis, process integration, scale-up strategies, and performance evaluation.	07	17
	TOTAL	**45**	**100%**

LIST OF PRACTICAL / TUTORIAL:

Sr. No	Practical / Tutorial	Hours
1	Introduction to conventional vs novel separation processes	02
2	Mechanisms and driving forces in advanced separations	02
3	Membrane separation classification and applications	02
4	Membrane fouling modeling and flux calculations	02
5	Adsorption isotherm analysis (Langmuir, Freundlich)	02

6	Breakthrough curve calculation for fixed-bed adsorbers	02
7	PSA and TSA cycle design problems	02
8	Supercritical CO_2 extraction design and calculations	02
9	Chromatographic separation principles and efficiency	02
10	Van Deemter equation and column optimization	02
11	Extractive & azeotropic distillation case studies	02
12	Hybrid separation system design problems	02
13	Electrodialysis and forward osmosis calculations	02
14	Bio separation design: protein purification	02
15	Industrial case studies: petrochemical, pharma, wastewater	02
	TOTAL	**30**

SELF-LEARNING ONLINE RESOURCES:

Sr. No	Link / Description	Self-Learning Hours
1	https://youtu.be/TEqYnV6KWfY?si=UzuKsaX_3VgvnzWf ; https://youtu.be/mAVswCbz_jM?si=CztpFDdGGhyUW2NX ; https://youtu.be/IZLn9_PA_4s?si=Ek9cgAi-S05WPGh6 ; Fundamentals of Novel Separation Processes	5
2	https://www.youtube.com/live/91Em1nze7K8?si=kFbWSBChEPkJPoAV ; https://youtu.be/TMQwDQ6eMXc?si=91NKmB5qmtSRoNWn ; https://youtu.be/NxE4xqHk218?si=Ico2bFLGx1hfPjPj ; Membrane-Based Separation Processes	5
3	https://youtu.be/K9teElePNkk?si=4hh3jbzvn1sdzd2m ; https://youtu.be/XZo4xyJXCak?si=e2gMdqhN29nhcx0w ; https://www.youtube.com/live/cezxxA7YA1g?si=m3d5Whhuz3ZSeSXt ; Adsorptive, Ion-Exchange and Supercritical Fluid Separations	5
4	https://youtu.be/vT5pcc30Ffw?si=2mz5nBppVC1pG5M1 ; https://youtu.be/NM53k7x_jjk?si=8BXymJU-xBXHyemM ; https://youtu.be/76ikqUXByrw?si=UWk7SbtnZxBN2kAm ; Chromatographic and Bio separation Techniques	5
5	https://www.youtube.com/live/Zf9NGO7qQhQ?si=hhVpU8e5TTKnm4EN ; https://youtu.be/6wW2dVrbx6s?si=rjeezftR9YdZJyGi ; https://www.youtube.com/live/VutajIhMMcc?si=0DvPuDEVsHB0tDij ; Advanced Distillation and Emerging Separation Technologies	5
6	https://youtu.be/PoAEZ1_GwZY?si=F99VgpJ9hpwtgcny ; https://youtu.be/8sP3kBs7Ppg?si=RDlpb4RfyHW_EvhV ; https://youtu.be/Kv2FnR1-it4?si=mqly56GJGs2ailBc ; Process Modelling, Simulation and Optimization of Separation Processes	5

COURSE EVALUATION & ASSESSMENT RUBRICS:

Component	CE/ESE	Evaluation Methodology / Rubrics	Marks	Passing Marks
Theory	CE	Two Internal Tests of 30 marks each shall be conducted during the semester. The average of both tests will be converted to 30 marks.	30	00
	ESE	Comprehensive written examination covering all modules of the course. Duration: 2 Hours	50	25

Tutorial	CE	Performance of practical which should be evaluated out of 10 marks for each practical and average of the same will be converted to 30 marks.	30	00
	ESE	Quiz / Practical Performance – 25Marks External Viva Voce – 25 Marks	50	25
Assignment	CE	Assignment Evaluation Rubrics Understanding & Coverage of Content– 5 Marks Analysis, Critical Thinking & Evidence– 5 Marks Structure, Flow & Organization– 5 Marks • Grammar, Style & Formatting/Referencing– 5 Marks	20	00
Self Learning	CE	40 MCQ questions based on self-study resources and online learning | 0.5 marks per question | Total = 20 marks	20	00
		TOTAL MARKS	**200**	**50**

TEXT BOOK(S):

Title	Author/s	Publication
Novel Separation Processes	Kakasani Ramesh, R. Shanthakumar	PHI Publications

REFERENCE BOOK(S):

Title	Author/s	Publication
Membrane Technology & Applications	Richard Baker	John Wiley & Sons (2023)
Supercritical Fluid Extraction: Technology Applications	Mohamed A. Abdel-Magid	CRC Press

COURSE OUTCOME(S):

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

SOECH7580	Advanced Separation Processes
CO 1	Explain the principles, mechanisms, and applications of novel separation processes.
CO 2	Analyze membrane, adsorptive, chromatographic, and hybrid separation systems.
CO 3	Design and evaluate supercritical, advanced distillation, and high-selectivity separation units.
CO 4	Apply novel separation techniques in chemical, petrochemical, pharmaceutical, food, and environmental industries.
CO 5	Critically evaluate process performance, sustainability, and economic feasibility of modern separation technologies.

MAPPING OF CO WITH PO:

SOECH7580	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	2	-	2	-	-	-	-	-	-	-
CO 2	2	3	-	3	2	-	-	-	-	-	-
CO 3	2	3	3	3	3	-	-	-	-	-	-

CO 4	1	2	3	2	2	-	-	-	-	2	-
CO 5	-	-	-	-	-	-	-	3	3	3	2

MAPPING OF CO WITH PSO:

SOECH7580	PSO1	PSO2	PSO3
CO 1	2	2	1
CO 2	3	2	2
CO 3	3	3	2
CO 4	2	3	2
CO 5	1	2	3

LEVEL OF REVISED BLOOM'S TAXONOMY IN ASSESSMENT

1: Remember	2: Understand	3: Apply
4: Analyze	5: Evaluate	6: Create

Module No	**Content**	**RBT Level**
1	Fundamentals of Novel Separation Processes	1,2
2	Membrane-Based Separation Processes	3
3	Adsorptive, Ion-Exchange and Supercritical Fluid Separations	3
4	Chromatographic and Bio separation Techniques	5
5	Advanced Distillation and Emerging Separation Technologies	4
6	Process Modelling, Simulation and Optimization of Separation Processes	6

P P Savani University
School of Engineering
Offered by: Department of Chemical Engineering

COURSE DETAILS:

Course Code	SOECH7590
Course Name	Reaction Engineering and Reactor Design
Prerequisite Course/s	None

TEACHING SCHEME:

Credit	Total Learning Hours	Direct Contact Hours			Indirect Contact Hours				
		Theory	Practical	Tutorial	Project	CS	Assignment	Term Work	Self-Learning
4	120	45	0	30	0	0	15	0	30

GD = Group Discussion | CS = Case Study | FV = Field Visit | PPT = Presentation

EXAMINATION SCHEME:

Theory		Practical		Tutorial		Project		CS		Assignment		Term Work		Self-Learning		Total
CE	ESE	CE	ESE	CE	ESE	CE	ESE	CE	ESE	CE	ESE	CE	ESE	CE	ESE	
30	50	0	0	30	50	0	0	0	0	20	00	0	0	20	00	200

CE: Continuous Evaluation, ESE: End Semester Exam

OBJECTIVE OF THE COURSE:

To help learners to:

- Strengthen advanced concepts of chemical reaction engineering including reactor design, kinetics, and transport interactions.
- Develop the ability to model, simulate, and analyze complex catalytic and non-catalytic reaction systems.
- Integrate reaction kinetics with heat and mass transfer limitations for industrial reactor design and scale-up.
- Enhance understanding of heterogeneous systems, multiphase reactors, and non-ideal flow behavior using modern computational tools.
- Develop problem-solving skills for real-world industrial reaction engineering challenges including optimization, safety, and reactor troubleshooting.

COURSE CONTENT:

Module No.	Content	Hours	Weightage in%
1	**Advanced Chemical Kinetics and Reaction Mechanisms:** Fundamentals of advanced reaction kinetics; elementary and non-elementary reactions; rate laws and reaction order determination; complex reaction networks; chain reactions and radical mechanisms; polymerization kinetics; enzyme kinetics; Langmuir–Hinshelwood and Eley–Rideal mechanisms; autocatalytic reactions; temperature dependence of reaction rates; Arrhenius equation; collision	07	15

	theory; transition state theory; ignition and extinction phenomena; reaction pathway analysis; micro-kinetic modeling.		
2	**Non-Ideal Flow Behavior and Residence Time Distribution:** Ideal and non-ideal reactors; residence time distribution (RTD); tracer techniques and RTD measurements; E-curve and F-curve analysis; tanks-in-series model; dispersion model and Peclet number; bypassing, channeling, and dead zones; flow diagnostics; segregation and maximum mixedness models; micro-mixing and macro-mixing; impact of non-ideal flow on reactor performance; model fitting and parameter estimation.	08	18
3	**Gas–Liquid and Gas–Solid Reaction Engineering:** Gas–liquid reaction systems; film theory and two-film theory; mass transfer with chemical reaction; Hatta number and enhancement factor; reaction regimes; gas absorption with reaction; gas–solid reaction models; shrinking core model; heterogeneous reaction kinetics; diffusion limitations; Thiele modulus and effectiveness factor; internal and external mass transfer resistances; catalytic gas–solid reactions; wetting efficiency and reactor applications.	08	18
4	**Heterogeneous Catalysis and Catalyst Engineering:** Fundamentals of heterogeneous catalysis; catalyst preparation and characterization; adsorption and surface reactions; adsorption isotherms and BET theory; active sites and turnover frequency; porous and supported catalysts; catalyst deactivation mechanisms including poisoning, sintering, coking, and fouling; catalyst regeneration techniques; diffusion limitations in catalytic systems; degradation kinetics; micro-kinetic modeling of catalytic reactions; industrial catalytic processes.	07	15
5	**Advanced Reactor Design, Modelling, and Simulation:** Design and analysis of PFR, CSTR, packed-bed, fluidized-bed, and multiphase reactors; reactor energy balance; heat effects in reactors; adiabatic and non-isothermal reactor operation; temperature profiles; autothermal reactors; runaway reactions and thermal stability; dynamic reactor modeling; reactor optimization and control; scale-up criteria; computational simulation using MATLAB, Python, Aspen Plus, and COMSOL; parameter estimation; sensitivity analysis; optimization techniques.	08	17
6	**Industrial Applications and Emerging Trends in Reaction Engineering:** Industrial reactor case studies: refinery reactors, polymer reactors, oxidation and hydrogenation processes, ammonia synthesis, reforming units, membrane reactors, bioreactors, pharmaceutical and wastewater treatment reactors; process safety and troubleshooting; process intensification; sustainability in reactor design; artificial intelligence and machine learning in reaction engineering; data-driven modeling; digital twins; photocatalytic and plasma reactors; microreactors; autonomous reactors; quantum chemistry-	07	17

	assisted mechanism prediction; advanced sensors and real-time monitoring.		
	TOTAL	**45**	**100%**

LIST OF PRACTICAL / TUTORIAL:

Sr. No	Practical / Tutorial	Hours
1	Complex reaction mechanisms, derivation of rate laws	02
2	Temperature dependency and Arrhenius calculations	02
3	Enzyme kinetics and catalytic mechanisms	02
4	RTD experiments, E-curve and F-curve interpretation	02
5	Modelling tanks-in-series and dispersion models	02
6	Gas–liquid reaction regimes and enhancement factors	02
7	Evaluation of Thiele modulus and effectiveness factor	02
8	Catalyst deactivation modelling	02
9	Design of PFR and CSTR for complex reactions	02
10	Non-isothermal reactor design and reactor stability	02
11	Modelling packed-bed and fluidized-bed reactors	02
12	Simulation of reactors using MATLAB/Python	02
13	Parameter estimation and curve fitting	02
14	Industrial case studies: ammonia synthesis, polymerization	02
15	Troubleshooting and safety analysis in reactors	02
	TOTAL	**30**

SELF-LEARNING ONLINE RESOURCES:

Sr. No	Link / Description	Self-Learning Hours
1	https://youtu.be/TEqYnV6KWfY?si=UzuKsaX_3VgvnzWf ; https://youtu.be/mAVswCbz_jM?si=CztpFDdGGhyUW2NX ; https://youtu.be/IZLn9_PA_4s?si=Ek9cgAi-S05WPGh6 ; Advanced Chemical Kinetics and Reaction Mechanisms	5
2	https://www.youtube.com/live/91Em1nze7K8?si=kFbWSBChEPkJPoAV ; https://youtu.be/TMQwDQ6eMXc?si=91NKmB5qmtSRoNWn ; https://youtu.be/NxE4xqHk218?si=Ico2bFLGx1hfPjPj ; Non-Ideal Flow Behavior and Residence Time Distribution	5
3	https://youtu.be/K9teElePNkk?si=4hh3jbzvn1sdzd2m ; https://youtu.be/XZo4xyJXCak?si=e2gMdqhN29nhcx0w ; https://www.youtube.com/live/cezxxA7YA1g?si=m3d5Whhuz3ZSeSXt ; Gas–Liquid and Gas–Solid Reaction Engineering	5
4	https://youtu.be/vT5pcc30Ffw?si=2mz5nBppVC1pG5M1 ; https://youtu.be/NM53k7x_jjk?si=8BXymJU-xBXHyemM ; https://youtu.be/76ikqUXByrw?si=UWk7SbtnZxBN2kAm ; Heterogeneous Catalysis and Catalyst Engineering	5
5	https://www.youtube.com/live/Zf9NGO7qQhQ?si=hhVpU8e5TTKnm4EN ; https://youtu.be/6wW2dVrbx6s?si=rjeezftR9YdZJyGi ; https://www.youtube.com/live/VutajIhMMcc?si=0DvPuDEVsHB0tDij ; Advanced Reactor Design, Modelling, and Simulation	5
6	https://youtu.be/PoAEZ1_GwZY?si=F99VgpJ9hpwtgcny ; https://youtu.be/8sP3kBs7Ppg? si=RDlpb4RfyHW_EvhV ;	5

	https://youtu.be/Kv2FnR1-it4?si=mqly56GJGs2ailBc ; Industrial Applications and Emerging Trends in Reaction Engineering	

COURSE EVALUATION & ASSESSMENT RUBRICS:

Component	CE/ESE	Evaluation Methodology / Rubrics	Marks	Passing Marks
Theory	CE	Two Internal Tests of 30 marks each shall be conducted during the semester. The average of both tests will be converted to 30 marks.	30	00
	ESE	Comprehensive written examination covering all modules of the course. Duration: 2 Hours	50	25
Tutorial	CE	Performance of practical which should be evaluated out of 10 marks for each practical and average of the same will be converted to 30 marks.	30	00
	ESE	Quiz / Practical Performance – 25Marks External Viva Voce – 25 Marks	50	25
Assignment	CE	Assignment Evaluation Rubrics Understanding & Coverage of Content– 5 Marks Analysis, Critical Thinking & Evidence– 5 Marks Structure, Flow & Organization– 5 Marks • Grammar, Style & Formatting/Referencing– 5 Marks	20	00
Self Learning	CE	40 MCQ questions based on self-study resources and online learning | 0.5 marks per question | Total = 20 marks	20	00
		TOTAL MARKS	**200**	**50**

TEXT BOOK(S):

Title	Author/s	Publication
Elements of Chemical Reaction Engineering	H. Scott Fogler	Prentice Hall (2022)

REFERENCE BOOK(S):

Title	Author/s	Publication
Chemical Reaction Engineering	Octave Levenspiel	Wiley (1998)
Chemical Reactor Analysis and Design	Froment & Bischoff	Wiley (2010)

COURSE OUTCOME(S):

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

SOECH7590	Reaction Engineering and Reactor Design
CO 1	Apply advanced kinetic models and mechanistic understanding for complex reaction systems.
CO 2	Analyze non-ideal flow behavior using RTD and diagnose reactor performance issues.
CO 3	Evaluate catalytic/multiphase reaction systems considering mass transfer and diffusion limitations.
CO 4	Design and model advanced reactors with coupled heat–mass–reaction phenomena.
CO 5	Use computational tools for simulation, optimization, and troubleshooting in industrial reaction engineering.

MAPPING OF CO WITH PO:

SOECH7590	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	2	-	2	-	-	-	-	-	-	-
CO 2	2	3	-	3	2	-	-	-	-	-	-
CO 3	2	3	3	3	3	-	-	-	-	-	-
CO 4	1	2	3	2	2	-	-	-	-	2	-
CO 5	-	-	-	-	-	-	-	3	3	3	2

MAPPING OF CO WITH PSO:

SOECH7590	PSO1	PSO2	PSO3
CO 1	2	2	1
CO 2	3	2	2
CO 3	3	3	2
CO 4	2	3	2
CO 5	1	2	3

LEVEL OF REVISED BLOOM'S TAXONOMY IN ASSESSMENT

1: Remember	2: Understand	3: Apply
4: Analyze	5: Evaluate	6: Create

Module No	Content	RBT Level
1	Advanced Chemical Kinetics and Reaction Mechanisms	1,2
2	Non-Ideal Flow Behavior and Residence Time Distribution	3
3	Gas–Liquid and Gas–Solid Reaction Engineering	3
4	Heterogeneous Catalysis and Catalyst Engineering	5
5	Advanced Reactor Design, Modelling, and Simulation	4
6	Industrial Applications and Emerging Trends in Reaction Engineering	6

P P Savani University

School of Engineering

Offered by: Department of Chemical Engineering

COURSE DETAILS:

Course Code	SOECH7600
Course Name	Process Dynamics and Advanced Control
Prerequisite Course/s	None

TEACHING SCHEME:

Credit	Total Learning Hours	Direct Contact Hours			Indirect Contact Hours				
		Theory	Practical	Tutorial	Project	CS	Assignment	Term Work	Self-Learning
4	120	45	0	30	0	0	15	0	30

GD = Group Discussion | CS = Case Study | FV = Field Visit | PPT = Presentation

EXAMINATION SCHEME:

Theory		Practical		Tutorial		Project		CS		Assignment		Term Work		Self-Learning		Total
CE	ESE	CE	ESE	CE	ESE	CE	ESE	CE	ESE	CE	ESE	CE	ESE	CE	ESE	
30	50	0	0	30	50	0	0	0	0	20	00	0	0	20	00	200

CE: Continuous Evaluation, ESE: End Semester Exam

OBJECTIVE OF THE COURSE:

To help learners to:

- Develop a comprehensive understanding of dynamic process modeling, advanced control methodologies, and optimization techniques applicable to chemical process systems.
- Gain proficiency in modern industrial control approaches, including multivariable control, Model Predictive Control (MPC), adaptive control, and other advanced process control strategies.
- Design, analyze, tune, and implement advanced control systems using simulation and computational tools such as MATLAB, Simulink, and Python.
- Address complex process control challenges involving nonlinear behavior, process interactions, constraints, uncertainties, and disturbances through robust and intelligent control techniques.
- Enhance analytical and problem-solving skills for process diagnostics, stability evaluation, performance assessment, real-time monitoring, and industrial process automation.

COURSE CONTENT:

Module No.	Content	Hours	Weightage in%
1	**Process Dynamics, Modeling and Control Fundamentals:** Dynamic process behavior, mathematical modeling of chemical processes, linearization techniques, Laplace transforms, transfer function models, interacting and non-interacting systems, FOPTD and SOPTD models, process gain, time constants, dead time, dynamic simulation, process nonlinearity, sensitivity analysis, frequency response analysis,	07	15

	Bode and Nyquist plots, Routh–Hurwitz stability criterion, introduction to process control performance evaluation.		
2	**Advanced PID Control and Industrial Control Structures:** PID controller fundamentals, controller tuning methods (Ziegler–Nichols, Cohen–Coon, IMC tuning), servo and regulatory control, performance indices, cascade control, ratio control, feedforward control, split-range control, selector and override control, dead-time compensation, Smith predictor, internal model control (IMC), disturbance rejection techniques, anti-reset windup and controller robustness.	08	18
3	**Multivariable Process Control and Interaction Analysis:** Multivariable (MIMO) process models, process interaction analysis, Relative Gain Array (RGA), pairing rules, decentralized control, decoupling strategies, steady-state gain matrix, controllability and observability concepts, singular value decomposition, condition number analysis, cross-coupling effects, non-square systems, industrial applications of multivariable control.	08	18
4	**Model Predictive, Adaptive and Intelligent Control Systems:** Model Predictive Control (MPC), prediction and control horizons, objective functions, dynamic matrix control (DMC), constrained optimization, state-space models, real-time optimization, adaptive control, gain scheduling, MRAC, self-tuning regulators, nonlinear control concepts, feedback linearization, Lyapunov stability, fuzzy logic control, neural network control, reinforcement learning-based control, robust and H-infinity control, soft sensors and process monitoring.	07	15
5	**Digital Control Systems and Discrete-Time Process Modeling:** Digital control architecture, sampling theory, aliasing, sample-and-hold devices, Z-transform and pulse transfer functions, discrete-time modeling, difference equations, discrete state-space models, Jury stability criterion, digital PID algorithms, implementation issues such as quantization and computational delays, discrete root locus, discrete-domain Bode and Nyquist plots, MATLAB/Python-based digital controller design for chemical processes.	08	17
6	**Industrial Automation, Smart Manufacturing and Advanced Applications:** Industrial sensors and smart instrumentation, field transmitters and communication protocols (HART, Foundation Fieldbus, Profibus), control valves and actuator dynamics, PLC architecture and programming concepts, DCS and SCADA systems, signal conditioning and calibration, fault detection and diagnosis (FDD), digital twins, Industry 4.0, AI/ML applications in process control, cloud-based monitoring, cybersecurity in automation systems, advanced industrial case studies from refineries, polymer plants, distillation columns, biochemical reactors, and intelligent manufacturing systems.	07	17
	TOTAL	**45**	**100%**

LIST OF PRACTICAL / TUTORIAL:

Sr. No	Practical / Tutorial	Hours
1	Basics of process dynamic modelling and linearization	02
2	Transfer function development and time-domain responses	02
3	Frequency response: Bode plot, Nyquist criteria	02
4	PID tuning using ZN, CC, and IMC methods	02
5	Cascade, ratio, and feedforward control problem solving	02
6	Dead-time compensation using Smith predictor & IMC	02
7	Performance indices evaluation (IAE, ISE, ITAE)	02
8	MIMO interaction: RGA, pairing rules	02
9	Decoupler design for 2×2 process	02
10	Introduction to MPC: formulation & constraints	02
11	Dynamic Matrix Control (DMC) example using MATLAB/Python	02
12	Adaptive control (MRAC, STR) calculations	02
13	Nonlinear control: feedback linearization examples	02
14	Fuzzy logic controller design	02
15	Case study: Advanced control in distillation/reformer/reactor	02
	TOTAL	**30**

SELF-LEARNING ONLINE RESOURCES:

Sr. No	Link / Description	Self-Learning Hours
1	https://youtu.be/TEqYnV6KWfY?si=UzuKsaX_3VgvnzWf ; https://youtu.be/mAVswCbz_jM?si=CztpFDdGGhyUW2NX ; https://youtu.be/IZLn9_PA_4s?si=Ek9cgAi-S05WPGh6 ; Process Dynamics, Modeling and Control Fundamentals	5
2	https://www.youtube.com/live/91Em1nze7K8?si=kFbWSBChEPkJPoAV ; https://youtu.be/TMQwDQ6eMXc?si=91NKmB5qmtSRoNWn ; https://youtu.be/NxE4xqHk218?si=Ico2bFLGx1hfPjPj ; Advanced PID Control and Industrial Control Structures	5
3	https://youtu.be/K9teElePNkk?si=4hh3jbzvn1sdzd2m ; https://youtu.be/XZo4xyJXCak?si=e2gMdqhN29nhcx0w ; https://www.youtube.com/live/cezxxA7YA1g?si=m3d5Whhuz3ZSeSXt ; Multivariable Process Control and Interaction Analysis	5
4	https://youtu.be/vT5pcc30Ffw?si=2mz5nBppVC1pG5M1 ; https://youtu.be/NM53k7x_jjk?si=8BXymJU-xBXHyemM ; https://youtu.be/76ikqUXByrw?si=UWk7SbtnZxBN2kAm ; Model Predictive, Adaptive and Intelligent Control Systems	5
5	https://www.youtube.com/live/Zf9NGO7qQhQ?si=hhVpU8e5TTKnm4EN ; https://youtu.be/6wW2dVrbx6s?si=rjeezftR9YdZJyGi ; https://www.youtube.com/live/VutajIhMMcc?si=0DvPuDEVsHB0tDij ; Digital Control Systems and Discrete-Time Process Modeling	5
6	https://youtu.be/PoAEZ1_GwZY?si=F99VgpJ9hpwtgcny ; https://youtu.be/8sP3kBs7Ppg?si=RDlpb4RfyHW_EvhV ; https://youtu.be/Kv2FnR1-it4?si=mqly56GJGs2ailBc ; Industrial Automation, Smart Manufacturing and Advanced Applications	5

COURSE EVALUATION & ASSESSMENT RUBRICS:

Component	CE/ESE	Evaluation Methodology / Rubrics	Marks	Passing Marks
Theory	CE	Two Internal Tests of 30 marks each shall be conducted during the semester. The average of both tests will be converted to 30 marks.	30	00
	ESE	Comprehensive written examination covering all modules of the course. Duration: 2 Hours	50	25
Tutorial	CE	Performance of practical which should be evaluated out of 10 marks for each practical and average of the same will be converted to 30 marks.	30	00
	ESE	Quiz / Practical Performance – 25Marks External Viva Voce – 25 Marks	50	25
Assignment	CE	Assignment Evaluation Rubrics Understanding & Coverage of Content– 5 Marks Analysis, Critical Thinking & Evidence– 5 Marks Structure, Flow & Organization– 5 Marks • Grammar, Style & Formatting/Referencing– 5 Marks	20	00
Self Learning	CE	40 MCQ questions based on self-study resources and online learning | 0.5 marks per question | Total = 20 marks	20	00
		TOTAL MARKS	**200**	**50**

TEXT BOOK(S):

Title	Author/s	Publication
Process Dynamics and Control	Dale E. Seborg, Thomas F. Edgar, Duncan Mellichamp	Wiley

REFERENCE BOOK(S):

Title	Author/s	Publication
Advanced Process Control	Paul Serban Agachi	De Gruyter
Model Predictive Control: Theory, Computation, and Design	James B. Rawlings, David Mayne	Nob Hill Publishing

COURSE OUTCOME(S):

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

SOECH7600	Process Dynamics and Advanced Control
CO 1	Develop and analyze dynamic models of chemical processes using linear and nonlinear techniques.
CO 2	Apply advanced PID-based and industrial control strategies for improved process performance.
CO 3	Evaluate interactions in multivariable systems and design appropriate MIMO control strategies.

CO 4	Formulate and implement Model Predictive Control (MPC) for constrained and multivariable processes.
CO 5	Design adaptive, nonlinear, and intelligent controllers for complex chemical processes.

MAPPING OF CO WITH PO:

SOECH7600	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	2	-	2		-	-	-	-	-	-
CO 2	2	3	-	3	2	-	-	-	-	-	-
CO 3	2	3	3	3	3	-	-	-	-	-	-
CO 4	1	2	3	2	2	-	-	-	-	2	-
CO 5	-	-	-	-	-	-	-	3	3	3	2

MAPPING OF CO WITH PSO:

SOECH7600	PSO1	PSO2	PSO3
CO 1	2	2	1
CO 2	3	2	2
CO 3	3	3	2
CO 4	2	3	2
CO 5	1	2	3

LEVEL OF REVISED BLOOM'S TAXONOMY IN ASSESSMENT

1: Remember	2: Understand	3: Apply
4: Analyze	5: Evaluate	6: Create

Module No	Content	RBT Level
1	Process Dynamics, Modeling and Control Fundamentals	1,2
2	Advanced PID Control and Industrial Control Structures	3
3	Multivariable Process Control and Interaction Analysis	3
4	Model Predictive, Adaptive and Intelligent Control Systems	5
5	Digital Control Systems and Discrete-Time Process Modeling	4
6	Industrial Automation, Smart Manufacturing and Advanced Applications	6

P P Savani University
School of Engineering
Offered by: Department of Chemical Engineering

P P Savani University

School of Engineering

Offered by: Department of Chemical Engineering

COURSE DETAILS:

Course Code	SOECH7610
Course Name	Soft Materials and Nanotechnology
Prerequisite Course/s	None

TEACHING SCHEME:

Credit	Total Learning Hours	Direct Contact Hours			Indirect Contact Hours				
		Theory	Practical	Tutorial	Project	CS	Assignment	Term Work	Self-Learning
4	120	45	0	30	0	0	15	0	30

GD = Group Discussion | CS = Case Study | FV = Field Visit | PPT = Presentation

EXAMINATION SCHEME:

Theory		Practical		Tutorial		Project		CS		Assignment		Term Work		Self-Learning		Total
CE	ESE	CE	ESE	CE	ESE	CE	ESE	CE	ESE	CE	ESE	CE	ESE	CE	ESE	
30	50	0	0	30	50	0	0	0	0	20	00	0	0	20	00	200

CE: Continuous Evaluation, ESE: End Semester Exam

OBJECTIVE OF THE COURSE:

To help learners to:

- Understand the fundamental concepts, principles, and classifications of soft matter and soft nanotechnology systems.
- Gain knowledge of intermolecular interactions, self-assembly processes, and fabrication techniques used in the development of soft nanomaterials.
- Familiar with modern characterization methods and the rheological, mechanical, and transport properties of soft materials.
- Explore the applications of soft nanotechnology in biomedical, environmental, energy, and industrial sectors.
- Acquire exposure to computational modeling, sustainability considerations, nanotoxicity, and emerging trends in soft nanotechnology and advanced materials.

COURSE CONTENT:

Module No.	Content	Hours	Weightage in%
1	**Fundamentals of Soft Nanotechnology and Soft Matter Systems: :** Introduction to soft matter and soft nanotechnology; polymers, colloids, gels, micelles, emulsions, foams, surfactants, liquid crystals, biomolecules, lipid bilayers, dendrimers, nanomicelles; viscoelasticity, Brownian motion, molecular interactions, entropic elasticity, thermal fluctuations; self-assembly in soft structures; fundamentals of soft matter.	07	15

2	**Intermolecular Interactions, Self-Assembly and Soft Material Fabrication: :** Van der Waals forces, hydrogen bonding, electrostatic and hydrophobic interactions, DLVO theory, steric stabilization, depletion forces, critical micelle concentration (CMC), block copolymer self-assembly, supramolecular chemistry, hierarchical self-assembly; solution processing, sol-gel methods, emulsion polymerization, layer-by-layer assembly, electrospinning, hydrogel synthesis, biomimetic assembly, microfluidic synthesis, soft lithography, nano-patterning and 3D printing of soft materials.	08	18
3	**Characterization and Analytical Techniques for Soft Nanomaterials: :** Dynamic Light Scattering (DLS), zeta potential, FTIR, UV–Vis, fluorescence spectroscopy, AFM, SEM, TEM, SAXS/WAXS, NMR, DSC, TGA, DMA, confocal microscopy, particle size and surface charge analysis, molecular weight distribution (GPC), rheological measurements, nanomechanical testing, structure–property correlations in soft materials.	08	18
4	**Soft Nanomaterial Dynamics, Rheology and Transport Phenomena: :** Rheology of soft nanomaterials, viscoelastic behavior, linear and nonlinear rheology, creep, stress relaxation, relaxation times, time–temperature superposition, shear thinning and thickening, yield stress materials, thixotropy; diffusion in soft systems, Fickian and non-Fickian transport, osmotic pressure, permeability of membranes, transport in gels and polymer networks, microrheology, particle tracking, rheo-optical techniques, nanoconfinement effects and flow behavior of complex fluids.	07	17
5	**Biological and Biomedical Applications of Soft Nanotechnology: :** Biopolymers, DNA nanotechnology, protein folding, lipid nanostructures, hydrogels for biomedical applications, liposomes, polymeric nanoparticles, drug delivery systems, tissue engineering scaffolds, biosensors, bio-inspired nanostructures, enzyme-assisted assembly, biocompatibility, cell-material interactions, targeted and stimuli-responsive delivery systems, nano-bio interactions, regenerative medicine and soft robotic materials.	08	17
6	**Computational Modeling, Industrial Applications, Sustainability and Emerging Trends: :** Molecular dynamics (MD), Monte Carlo methods, dissipative particle dynamics (DPD), mesoscale and multiscale modeling, CFD for soft matter systems, phase-field modeling, simulation of self-assembly, AI/ML in soft nanotechnology, digital twins and data-driven materials discovery; industrial applications in coatings, pharmaceuticals, cosmetics, food engineering, packaging and adhesives; green nanotechnology, nanotoxicology, risk assessment, sustainability, circular material design, soft electronics, wearable sensors, flexible devices, energy harvesting, environmental remediation and future trends.	07	15

	TOTAL	**45**	**100%**

LIST OF PRACTICAL / TUTORIAL:

Sr. No	Practical / Tutorial	Hours
1	Introduction to soft matter, types, molecular interactions	02
2	Colloids, gels, surfactants, polymeric soft systems	02
3	Self-assembly: micelles, vesicles, block copolymers	02
4	Intermolecular forces & DLVO theory	02
5	Hydrogels & soft nanocomposites	02
6	Fabrication methods – sol-gel, LbL, electrospinning	02
7	Soft lithography and patterning principles	02
8	DLS, zeta potential, particle size analysis	02
9	AFM, SEM, TEM for soft materials	02
10	Rheology & viscoelastic behavior tutorials	02
11	Biological soft materials & biomimetic systems	02
12	Drug delivery soft nanocarriers	02
13	Smart/stimuli-responsive materials	02
14	Nanotoxicity, safety protocols, sustainability	02
15	Case studies: soft electronics, sensors, soft robots	02
	TOTAL	**30**

SELF-LEARNING ONLINE RESOURCES:

Sr. No	Link / Description	Self-Learning Hours
1	https://youtu.be/TEqYnV6KWfY?si=UzuKsaX_3VgvnzWf ; https://youtu.be/mAVswCbz_jM?si=CztpFDdGGhyUW2NX ; https://youtu.be/IZLn9_PA_4s?si=Ek9cgAi-S05WPGh6 ; Fundamentals of Soft Nanotechnology and Soft Matter Systems	5
2	https://www.youtube.com/live/91Em1nze7K8?si=kFbWSBChEPkJPoAV ; https://youtu.be/TMQwDQ6eMXc?si=91NKmB5qmtSRoNWn ; https://youtu.be/NxE4xqHk218?si=Ico2bFLGx1hfPjPj ; Intermolecular Interactions, Self-Assembly and Soft Material Fabrication	5
3	https://youtu.be/K9teElePNkk?si=4hh3jbzvn1sdzd2m ; https://youtu.be/XZo4xyJXCak?si=e2gMdqhN29nhcx0w ; https://www.youtube.com/live/cezxxA7YA1g?si=m3d5Whhuz3ZSeSXt ; Characterization and Analytical Techniques for Soft Nanomaterials	5
4	https://youtu.be/vT5pcc30Ffw?si=2mz5nBppVC1pG5M1 ; https://youtu.be/NM53k7x_jjk?si=8BXymJU-xBXHyemM ; https://youtu.be/76ikqUXByrw?si=UWk7SbtnZxBN2kAm ; Soft Nanomaterial Dynamics, Rheology and Transport Phenomena	5
5	https://www.youtube.com/live/Zf9NGO7qQhQ?si=hhVpU8e5TTKnm4EN ; https://youtu.be/6wW2dVrbx6s?si=rjeezftR9YdZJyGi ; https://www.youtube.com/live/VutajIhMMcc?si=0DvPuDEVsHB0tDij ; Biological and Biomedical Applications of Soft Nanotechnology	5
6	https://youtu.be/PoAEZ1_GwZY?si=F99VgpJ9hpwtgcny ; https://youtu.be/8sP3kBs7Ppg?si=RDlpb4RfyHW_EvhV ; https://youtu.be/Kv2FnR1-it4?si=mqly56GJGs2ailBc ; Computational Modeling, Industrial Applications, Sustainability and Emerging Trends	5

COURSE EVALUATION & ASSESSMENT RUBRICS:

Component	CE/ESE	Evaluation Methodology / Rubrics	Marks	Passing Marks
Theory	CE	Two Internal Tests of 30 marks each shall be conducted during the semester. The average of both tests will be converted to 30 marks.	30	00
	ESE	Comprehensive written examination covering all modules of the course. Duration: 2 Hours	50	25
Tutorial	CE	Performance of practical which should be evaluated out of 10 marks for each practical and average of the same will be converted to 30 marks.	30	00
	ESE	Quiz / Practical Performance – 25Marks External Viva Voce – 25 Marks	50	25
Assignment	CE	Assignment Evaluation Rubrics Understanding & Coverage of Content– 5 Marks Analysis, Critical Thinking & Evidence– 5 Marks Structure, Flow & Organization– 5 Marks • Grammar, Style & Formatting/Referencing– 5 Marks	20	00
Self Learning	CE	40 MCQ questions based on self-study resources and online learning | 0.5 marks per question | Total = 20 marks	20	00
		TOTAL MARKS	**200**	**50**

TEXT BOOK(S):

Title	Author/s	Publication
Soft Nanotechnology	T. M. Squires & S. R. Quake	Oxford University Press (2005)

REFERENCE BOOK(S):

Title	Author/s	Publication
Introduction to Soft Matter: Synthetic and Biological Self-Assembling Materials	Ian W. Hamley	Wiley (2007)
Principles of Colloid and Surface Chemistry	Paul C. Hiemenz, Raj Rajagopalan	CRC Press (1997)

COURSE OUTCOME(S):

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

SOECH7610	Soft Materials and Nanotechnology
CO 1	Explain the fundamental physics, chemistry, and behavior of soft nanomaterials and soft matter systems.
CO 2	Analyze intermolecular interactions and self-assembly mechanisms governing nanoscale behaviour.
CO 3	Apply fabrication and processing techniques for developing functional soft nanostructures.

CO 4	Select and use appropriate characterization tools for analyzing structural, mechanical, and dynamic properties of soft nanomaterials.
CO 5	Evaluate applications, sustainability, environmental impact, and emerging technologies in soft nanotechnology.

MAPPING OF CO WITH PO:

SOECH7610	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	2	-	2		-	-	-	-	-	-
CO 2	2	3	-	3	2	-	-	-	-	-	-
CO 3	2	3	3	3	3	-	-	-	-	-	-
CO 4	1	2	3	2	2	-	-	-	-	2	-
CO 5	-	-	-	-	-	-	-	3	3	3	2

MAPPING OF CO WITH PSO:

SOECH7610	PSO1	PSO2	PSO3
CO 1	2	2	1
CO 2	3	2	2
CO 3	3	3	2
CO 4	2	3	2
CO 5	1	2	3

LEVEL OF REVISED BLOOM'S TAXONOMY IN ASSESSMENT

1: Remember	2: Understand	3: Apply
4: Analyze	5: Evaluate	6: Create

Module No	Content	RBT Level
1	Fundamentals of Soft Nanotechnology and Soft Matter Systems	1,2
2	Intermolecular Interactions, Self-Assembly and Soft Material Fabrication	3
3	Characterization and Analytical Techniques for Soft Nanomaterials	3
4	Soft Nanomaterial Dynamics, Rheology and Transport Phenomena	5
5	Biological and Biomedical Applications of Soft Nanotechnology	4
6	Computational Modeling, Industrial Applications, Sustainability and Emerging Trends	6

P P Savani University

School of Engineering

Offered by: Department of Chemical Engineering

COURSE DETAILS:

Course Code	SOECH7620
Course Name	Advanced Characterization of Polymeric Materials
Prerequisite Course/s	None

TEACHING SCHEME:

Credit	Total Learning Hours	Direct Contact Hours			Indirect Contact Hours				
		Theory	Practical	Tutorial	Project	CS	Assignment	Term Work	Self-Learning
4	120	45	0	30	0	0	15	0	30

GD = Group Discussion | CS = Case Study | FV = Field Visit | PPT = Presentation

EXAMINATION SCHEME:

Theory		Practical		Tutorial		Project		CS		Assignment		Term Work		Self-Learning		Total
CE	ESE	CE	ESE	CE	ESE	CE	ESE	CE	ESE	CE	ESE	CE	ESE	CE	ESE	
30	50	0	0	30	50	0	0	0	0	20	00	0	0	20	00	200

CE: Continuous Evaluation, ESE: End Semester Exam

OBJECTIVE OF THE COURSE:

To help learners to:

- Understand the sources, characteristics, and pollution impacts of wastewater and the need for physico-chemical treatment methods.
- Apply principles of pre-treatment, primary treatment, sedimentation, filtration, and coagulation–flocculation processes in wastewater management.
- Analyze the performance of advanced physico-chemical treatment technologies such as adsorption, ion exchange, membrane separation, and advanced oxidation processes.
- Evaluate suitable treatment schemes for industrial wastewater based on pollutant characteristics, regulatory requirements, and process economics.
- Develop sustainable wastewater treatment strategies incorporating emerging technologies, water reuse, resource recovery, and zero liquid discharge concepts.

COURSE CONTENT:

Module No.	Content	Hours	Weightage in%
1	**Fundamentals of Polymer Characterization:** Polymer structure and molecular architecture; homopolymers, copolymers, polymer chain conformations; amorphous and crystalline polymers; glass transition temperature (Tg), melting temperature (Tm); viscoelastic behavior; polymer phase behavior; physical aging; sample preparation techniques; ASTM and ISO testing standards; quality control and purity assessment methods.	07	15

2	**Molecular and Spectroscopic Characterization:** Molecular weight concepts (Mn, Mw, Mz) and molecular weight distribution; polydispersity index (PDI); Gel Permeation Chromatography (GPC); dilute solution viscometry and Mark–Houwink equation; osmometry; static and dynamic light scattering (DLS); MALDI-TOF analysis; Nuclear Magnetic Resonance (NMR); Fourier Transform Infrared Spectroscopy (FTIR); functional group identification and spectral interpretation.	08	18
3	**Thermal Characterization Techniques:** Differential Scanning Calorimetry (DSC); Thermogravimetric Analysis (TGA); Differential Thermal Analysis (DTA); Thermomechanical Analysis (TMA); determination of glass transition, melting behavior, crystallinity, heat of fusion, oxidative stability; thermal degradation mechanisms; thermal stability assessment and thermogram interpretation.	08	18
4	**Mechanical and Rheological Characterization:** Tensile, compression, flexural and impact testing; modulus, elongation at break, hardness measurements; Dynamic Mechanical Analysis (DMA); storage modulus, loss modulus and damping factor (tan δ); creep and stress relaxation; rheometry; oscillatory shear measurements; flow behavior of polymer melts; melt flow index (MFI); viscoelastic characterization and fracture analysis.	07	15
5	**Morphological and Structural Characterization:** Optical and polarized light microscopy; Scanning Electron Microscopy (SEM); Transmission Electron Microscopy (TEM); X-ray Diffraction (XRD), WAXD and SAXS; crystalline morphology, spherulites and lamellar structures; phase separation; nanocomposite morphology; filler dispersion; interface characterization; microstructural analysis of polymer composites.	08	17
6	**Characterization of Elastomers, Composites and Industrial Applications:** Rubber elasticity and crosslink density; vulcanization analysis; Mooney viscosity; cure characteristics; resilience, abrasion and fatigue testing; swelling behavior and thermal aging; characterization of fiber-reinforced composites; fiber orientation and interfacial adhesion; composite failure analysis; industrial case studies in packaging, automotive, biomedical, aerospace and sustainable polymer systems; recyclability and quality control applications.	07	17
	TOTAL	**45**	**100%**

LIST OF PRACTICAL / TUTORIAL:

Sr. No	Practical / Tutorial	Hours
1	Introduction to polymer structure and need for characterization	02
2	Sample preparation and conditioning methods	02
3	Molecular weight analysis using GPC and viscometry	02
4	FTIR and NMR interpretation for common polymers	02
5	DSC thermogram interpretation and crystallinity calculation	02

6	TGA decomposition kinetics and thermal stability	02
7	DMA modulus interpretation and viscoelastic analysis	02
8	Rheology: MFI, viscosity curves, oscillatory shear	02
9	SEM sample preparation and microstructure identification	02
10	XRD pattern analysis and crystallinity estimation	02
11	Elastomer testing: Mooney viscosity, cure curves	02
12	Composite mechanical testing and failure analysis	02
13	Case studies of polymer degradation and recycling	02
14	Industrial QC methods for polymers and composites	02
15	Instrumentation selection for real-world applications	02
	TOTAL	**30**

SELF-LEARNING ONLINE RESOURCES:

Sr. No	**Link / Description**	**Self-Learning Hours**
1	https://youtu.be/I12V6miSlks?si=uOqAIUVD33P6tOih ; https://youtu.be/s9ah7DUl-es?si=0UpsiQfLRChZuZ0x ; https://youtu.be/SD1umo4EtBI?si=ll_EAbeRfoSh3aiG ; Fundamentals of Polymer Characterization	5
2	https://youtu.be/-8tUsgo8u_o?si=1zgjOOnbt1PaLfAh ; https://youtu.be/WMdnptwEfhk?si=G9J6tZ9R6_F1g1uB ; https://youtu.be/ocjFXQTKerU?si=58BijQ686JvxuZ2K ; Molecular and Spectroscopic Characterization	5
3	https://youtu.be/b_wh86J_Jxw?si=T3JL4pyBU6HPRqV8 ; https://youtu.be/vQCje_lXHaA?si=1abTmjnpjY-csY5S ; https://youtu.be/mSaoHOvLwYk?si=x9zobmzzP0GHP3Dx ; Thermal Characterization Techniques	5
4	https://youtu.be/UuCNYp7CMfo?si=-NZSpuJST_dOWo9f ; https://youtu.be/c2GsM5s46oo?si=itmVy6yqiqRXRb9x ; https://youtu.be/dIl_oGPUSfg?si=RKOUOKhIDBB7DJ_g ; Mechanical and Rheological Characterization	5
5	https://youtu.be/Ke3ygwnggTw?si=m4KFrgunQNzQnkZI ; https://youtu.be/-0kKPEGbyx0?si=oqgPbXc9YjsCwSId ; https://youtu.be/xQouJ_zMHQ8?si=KYrDNa6p7pppVOQF ; Morphological and Structural Characterization	5
6	https://youtu.be/3agloWbJiuQ?si=jVjx2IEdze4z0N6L ; https://youtu.be/5rAySDzsXsQ?si=ZHBl12nL9W4xLbsK ; Characterization of Elastomers, Composites and Industrial Applications	5

COURSE EVALUATION & ASSESSMENT RUBRICS:

Component	**CE/ESE**	**Evaluation Methodology / Rubrics**	**Marks**	**Passing Marks**
Theory	CE	Two Internal Tests of 30 marks each shall be conducted during the semester. The average of both tests will be converted to 30 marks.	30	00
	ESE	Comprehensive written examination covering all modules of the course. Duration: 2 Hours	50	25

Tutorial	CE	Performance of practical which should be evaluated out of 10 marks for each practical and average of the same will be converted to 30 marks.	30	00
	ESE	Quiz / Practical Performance – 25Marks External Viva Voce – 25 Marks	50	25
Assignment	CE	Assignment Evaluation Rubrics Understanding & Coverage of Content– 5 Marks Analysis, Critical Thinking & Evidence– 5 Marks Structure, Flow & Organization– 5 Marks • Grammar, Style & Formatting/Referencing– 5 Marks	20	00
Self Learning	CE	40 MCQ questions based on self-study resources and online learning | 0.5 marks per question | Total = 20 marks	20	00
		TOTAL MARKS	**200**	**50**

TEXT BOOK(S):

Title	**Author/s**	**Publication**
Polymer Science and Technology	Joel R. Fried	Prentice Hall (2007)

REFERENCE BOOK(S):

Title	**Author/s**	**Publication**
Polymer Characterization: Physical Techniques	D. Campbell & J.R. White	CRC Press
Composite Materials: Science and Engineering	K.K. Chawla	Springer

COURSE OUTCOME(S):

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

SOECH7620	**Advanced Characterization of Polymeric Materials**
CO 1	Explain fundamental characterization techniques and select appropriate methods for polymer, elastomer, and composite analysis.
CO 2	Interpret molecular weight, thermal, mechanical, and rheological data to evaluate polymer performance.
CO 3	Analyze microstructure and morphology using SEM, TEM, XRD, and optical microscopy.
CO 4	Perform characterization of elastomers and composites and interpret advanced material behavior.
CO 5	Apply characterization data for industrial quality control, failure diagnosis, and materials development.

MAPPING OF CO WITH PO:

SOECH7620	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	2	-	2		-	-	-	-	-	-
CO 2	2	3	-	3	2	-	-	-	-	-	-
CO 3	2	3	3	3	3	-	-	-	-	-	-
CO 4	1	2	3	2	2	-	-	-	-	2	-
CO 5	-	-	-	-	-	-	-	3	3	3	2

MAPPING OF CO WITH PSO:

SOECH7620	PSO1	PSO2	PSO3
CO 1	2	2	1
CO 2	3	2	2
CO 3	3	3	2
CO 4	2	3	2
CO 5	1	2	3

LEVEL OF REVISED BLOOM'S TAXONOMY IN ASSESSMENT

1: Remember	2: Understand	3: Apply
4: Analyze	5: Evaluate	6: Create

Module No	Content	RBT Level
1	Fundamentals of Polymer Characterization	1,2
2	Molecular and Spectroscopic Characterization	3
3	Thermal Characterization Techniques	3
4	Mechanical and Rheological Characterization	5
5	Morphological and Structural Characterization	4
6	Characterization of Elastomers, Composites and Industrial Applications	6