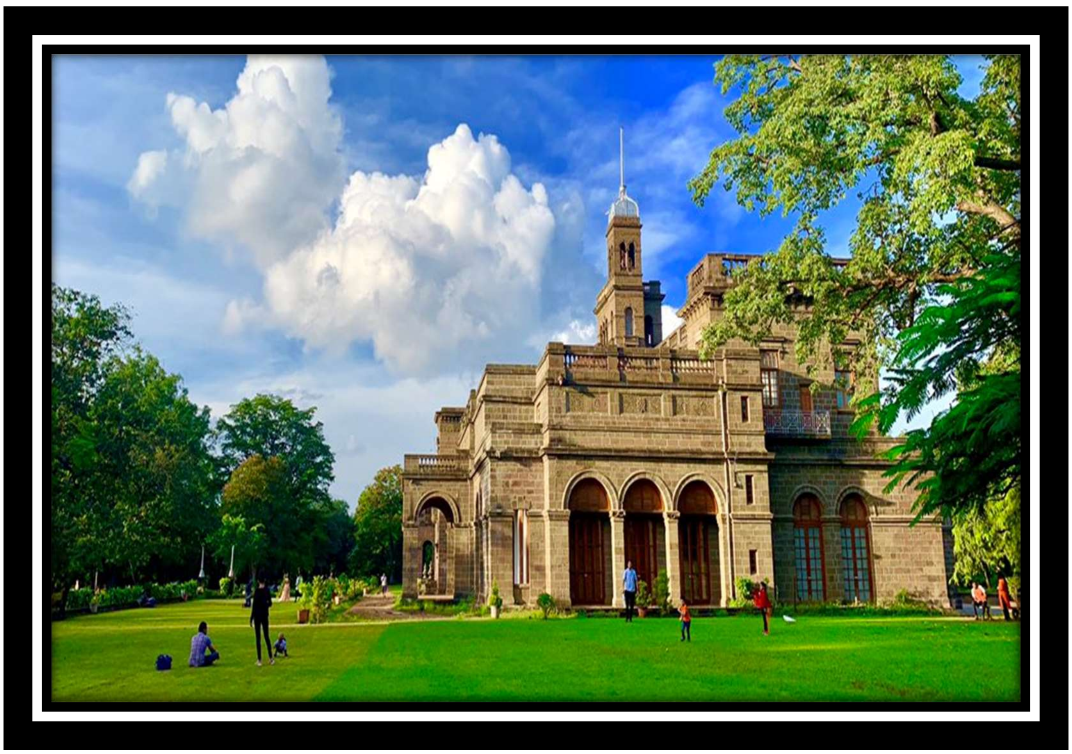
सावित्रीबाई फुले पुणे विद्यापीठ

Savitribai Phule Pune University, Pune, Maharashtra, India

Faculty of Science and Technology



National Education Policy (NEP) -2020 Compliant Curriculum

Third Year Engineering (2024 Pattern)
Chemical Engineering

(With effect from Academic Year 2026-27)

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Preface by Board of Studies

Dear Students and Teachers,

We are the members of Board of Studies in Chemical and Petroleum Engineering are pleased to present the revised Third Year Chemical Engineering curriculum as per the 2024 Pattern, effective from the Academic Year 2026–27. The curriculum has been thoroughly revised, upgraded and designed in sprit and objectives of NEP-2020, AICTE, UGC, and Savitribai Phule Pune University, with due emphasis on outcome-based education, multidisciplinary learning, and industry readiness.

The syllabus embraces the classic and core subjects of Chemical Engineering fraternity, namely Mass Transfer, Reaction Engineering I and II, Separation Processes and Transport Phenomena in addition to important multidisciplinary subjects namely, Applied Numerical Techniques, Process Instrumentation and Control, Thermodynamics, Analytical Techniques and Sustainability etc.

Most of the core subjects and the specialized electives are coupled with relevant laboratory courses to provide learners practical usefulness of subjects along with analytical skills. A wide range of elective courses and skill enhancement courses including Computational Fluid Dynamics, AI Applications in Chemical Engineering, Solar Technology and Maintenance, Environmental Engineering, etc. have been incorporated to address emerging technological advancements and industrial requirements.

Major thrust of the syllabus was laid on teaching – learning process with key emphasize on development of innovative mindset, skill enhancement, adaptability of the students through various courses, Open Electives, Technical Seminar, Vocational Skill Courses, and Internship/On-Job Training. Students are encouraged to undertake self-learning through platforms such as NPTEL and SWAYAM to enhance their technical and professional competencies.

The curriculum has been developed through extensive consultation with academic experts, industry professionals, and alumni to ensure its relevance and academic excellence. It is designed to align with current industry standards while equipping students with the knowledge and skills required for competitive examinations, higher studies, and research in the field of Chemical Engineering.

Dr. Somnath Nandi
Coordinator
Board of Studies (Chemical & Petroleum Engineering)

Members of Board of Studies Chemical & Petroleum Engineering	
Dr. Makrand Naniwadekar	Dr. Jotiram Gujar
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Nomenclature

AEC	Ability Enhancement Course
CEP	Community Engagement Project
EEM	Entrepreneurship/Economics/ Management
FP	Field Project
MDM	Multidisciplinary Minor
OEL	Open Elective
PCC	Programme Core Course
PEO	Programme Educational Objectives
PO	Program Outcomes
PSO	Program Specific Outcomes
SEC	Skill Enhancement Courses
VEC	Value Education Course
VSC	Vocational Skill Courses
VSEC	Vocational and Skill Enhancement Course
WK	Knowledge and Attitude Profile

Program Specific Outcomes

PSO1 (Core Competency): Demonstrate a solid foundation in chemical engineering principles and apply them to real-world problems through conceptual clarity, practical experience, and interdisciplinary integration.

PSO2 (Analysis, Upscaling and Decision-Making Skills): Apply engineering mathematics, numerical methods, and various programming tools to model, simulate, and analyze chemical engineering and allied problems, enabling effective decision-making.

PSO3 (Successful Career and Entrepreneurship): Exhibit readiness for professional careers and entrepreneurial pursuits by leveraging core chemical engineering knowledge, innovation, and problem-solving abilities to create sustainable and practical solutions addressing societal and industrial challenges.

Program Educational Objectives (PEOs)

PEO	PEO Focus	PEO Statement
PEO1	Core Competency	Graduates will establish themselves as competent professionals through application of fundamental chemical engineering principles to analyze, design, and upscale chemical and allied processes.
PEO2	Ethical, Social, and Global Responsibilities	Graduates will demonstrate professionalism, ethical conduct, and a strong sense of societal and environmental responsibility, while effectively collaborating in multidisciplinary teams and contributing to both national and global development.
PEO3	Professional Growth and Lifelong Learning	Graduates will engage in higher education, professional certifications, or self-directed learning to continuously expand their knowledge and remain updated with recent advancements in chemical engineering and other domain.

Knowledge and Attitude Profile (WK)

A Knowledge and Attitude Profile (KAP), also referred to as Knowledge and Attribute Profile (WK) in some contexts, is a framework or assessment tool used to evaluate an individual's knowledge and attitudes within a specific area, topic, or domain.

PO No	Title	Program Outcome Description
WK1	Natural Science and Social Sciences	A systematic, theory-driven framework for understanding natural sciences, with applications in both specific discipline and the social sciences.
WK2	Mathematics and Data Analysis	Conceptually grounded mathematics, numerical analysis, statistics, and computer science knowledge used to understand, support, and model phenomena relevant to the discipline.
WK3	Engineering Fundamentals	A systematic, theory-based formulation of fundamental engineering principles essential to the discipline.
WK4	Engineering Specialist Knowledge	Specialist engineering knowledge that offers theoretical frameworks and established bodies of knowledge underpinning accepted practice areas, much of which is at the forefront of the discipline.
WK5	Engineering Design and Environmental Considerations	Knowledge encompassing efficient resource usage, environmental impact, whole-life cost, net-zero carbon, and related concepts that inform and support engineering design and operations within specific practice area.
WK6	Engineering Practice (Technology)	Knowledge of engineering practices and technologies relevant to the core and allied areas of the discipline.
WK7	Role of Engineering in Society	Understanding the role of engineering in society and key issues in professional practice, including an engineer's responsibility for public safety and commitment to sustainable development.
WK8	Research and Critical Thinking	Engagement with current research literature in the discipline, coupled with an awareness of the value of critical thinking and creative approaches in evaluating emerging issues.
WK9	Ethics and Inclusive Behavior	Understanding of professional ethics, responsibilities, and standards of engineering practice, alongside a commitment to ethical conduct, inclusive behavior, and respect for diversity across ethnicity, gender, age, physical ability, and other attributes.

Program Outcomes (POs)

Program Outcomes (POs) are statements defining knowledge, skills, and abilities students are expected to demonstrate upon graduating from the program. These outcomes align with the program's educational objectives and encompass the competencies, attitudes, and behaviors developed throughout the students' academic experience. Upon successful completion of the B.E. in Chemical Engineering, graduates will be able to:

PO No	Title	Program Outcome Description
PO1	Engineering Knowledge	Apply knowledge of mathematics, chemistry, physics, and core chemical engineering principles as specified in WK1 to WK4 respectively to solve complex engineering problems.
PO2	Problem Analysis	Identify, formulate, and analyze chemical engineering problems using scientific principles, computational tools, and experimental data (WK1 to WK4).
PO3	Design/Development of Solutions	Design processes, equipment, and systems (reactors, distillation columns, heat exchangers, etc.) considering safety, sustainability, and economic constraints (WK5).
PO4	Conduct Investigation of Complex Problem	Conduct experiments, analyze data, and interpret results using modern instrumentation, simulation software and statistical tools (WK2, WK3 and WK8).
PO5	Engineering Tool Usage	Use industry-standard software, programming, and AI/ML techniques for process modeling, optimization, and automation (WK2 and WK6).
PO6	The Engineer and the World	Understand the social, environmental, and ethical responsibilities of chemical engineers in areas like pollution control, green chemistry, and sustainable development and comply with environmental regulations (WK1, WK5 and WK7).
PO7	Ethics	Follow professional ethics, safety protocols and workplace standards in chemical industries (WK9).
PO8	Individual and Collaborative Teamwork	Function effectively as an individual or in multidisciplinary teams in plant operations and R&D (WK 8 and WK9).
PO9	Communication	Communicate technical concepts clearly through reports, presentations, and documentation for industry and academia (WK 6, WK 8 and WK9).
PO10	Project Management and Finance	Apply engineering economics, risk assessment, and project management principles to optimize industrial processes (WK1, WK4 and WK6) .
PO11	Lifelong Learning	Engage in continuous learning through various certifications, higher studies (GATE, GRE, CAT, GMAT etc.), or adapting to new technologies (Industry 4.0, circular economy) (WK8).

General Rules and Guidelines

Course Outcomes (CO): Course Outcomes are narrower statements that describe what students are expected to know, and are able to do at the end of each course. These relate to the skills, knowledge and behaviour that students acquire in their progress through the course.

• **Assessment:** Assessment is one or more processes, carried out by the institution, that identify, collect, and prepare data to evaluate the achievement of Program Educational Objectives and Program Outcomes.

• **Evaluation:** Evaluation is one or more processes, done by the Evaluation Team, for interpreting the data and evidence accumulated through assessment practices. Evaluation determines the extent to which Program Educational Objectives or Program Outcomes are being achieved, and results in decisions and actions to improve the program.

Guidelines for Exam Scheme

Theory Examination: The theory examination shall be conducted in two different parts Comprehensive Continuous Evaluation (CCE) and End-Semester Examination (ESE).

- Comprehensive Continuous Evaluation (CCE) of 30 marks based on all the Units of course syllabus to be scheduled and conducted at institute level. To design a Comprehensive Continuous Evaluation (CCE) scheme for a theory subject of 30 marks with the specified parameters, the allocation of marks and the structure can be detailed as follows:

Sr. No.	Parameters	Marks	Coverage of Units
1	Unit Test	12 Marks	Units 1 and 2 (6 Marks / unit)
2	Assignment / Case Study	12 Marks	Units 3 and 4 (6 Marks / unit)
3	Seminar Presentation / Open Book Test / Quiz	06 Marks	Unit 5

- Comprehensive Continuous Evaluation (CCE) of 15 marks based on all the Units of course syllabus to be scheduled and conducted at institute level. To design a Comprehensive Continuous Evaluation (CCE) scheme for a theory subject of 15 marks with the specified parameters, the allocation of marks and the structure can be detailed as follows:

Sr. No.	Parameter	Marks	Coverage of Units
1	Unit Test	10 Marks	Units 1 and Unit 2 (5 Marks/Unit)
2	Seminar Presentation / Open Book Test/ Assignments / Case Study	05 Marks	Units 3 and Unit 4

Format and Implementation of Comprehensive Continuous Evaluation (CCE)

• **Unit Test**

– **Format:** Questions designed as per Bloom's Taxonomy guidelines to assess various cognitive levels (Remember, Understand, Apply, Analyze, Evaluate, Create).

– **Implementation:** Schedule the test after completing Units 1 and 2. Ensure the question paper is balanced and covers key concepts and applications.

• **Sample Question Distribution**

– Remembering (2 Marks): Define key terms related to [Topic from Units 1 and 2].
– Understanding (2 Marks): Explain the principle of [Concept] in [Context].
– Applying (2 Marks): Demonstrate how [Concept] can be used in [Scenario].
– Analyzing (3 Marks): Compare & contrast [Two related concepts] from Units 1 and 2.
– Evaluating (3 Marks): Evaluate the effectiveness of [Theory/Model] in [Situation].

• **Assignments / Case Study:** Students should submit one assignment or one Case Study Report based on Unit 3 and one assignment or one Case Study Report based on Unit 4.

– **Format:** Problem-solving tasks, theoretical questions, practical exercises, or case studies that require in-depth analysis and application of concepts.

– **Implementation:** Distribute the assignments or case study after covering Units 3 and 4. Provide clear guidelines and a rubric for evaluation.

• **Seminar Presentation:**

– Format: Oral presentation on a topic from Unit 5, followed by a Q&A session.

– Deliverables: Presentation slides, a summary report in 2 to 3 pages, and performance during the presentation.

– Implementation: Schedule the seminar presentations towards the end of the course. Provide students with ample time to prepare and offer guidance on presentation skills.

• **Open Book Test:**

– Format: Analytical and application-based questions to assess depth of understanding.

– Implementation: Schedule the open book test towards the end of the course, ensuring it covers critical aspects of Unit 5.

• **Quiz:**

– **Format:** Quizzes can help students practice existing knowledge while stimulating interest in learning about new topic in that course. You can set your quizzes to be completed individually or in small groups.

– **Implementation:** Online tools and software can be used create quiz. Each quiz is made up of a variety of question types including multiple choice, missing words, true or false etc.

• **Example Timeline for conducting CCE:**

– Weeks 1-4 : Cover Units 1 and 2
– Week 5 : Conduct Unit Test (12 marks)
– Weeks 6-8 : Cover Units 3 and 4
– Week 9 : Distribute and collect Assignments / Case Study (12 marks)
– Weeks 10-12 : Cover Unit 5
– Week 13 : Conduct Seminar Presentations or Open Book Test or Quiz (6 marks)

• **Evaluation and Feedback:**

– Unit Test: Evaluate promptly and provide constructive feedback on strengths and areas for improvement.

– Assignments / Case Study: Assess the quality of submissions based on the provided rubric. Offer feedback to help students understand their performance.

– Seminar Presentation: Evaluate based on content, delivery, and engagement during the Q&A session. Provide feedback on presentation skills and comprehension of the topic.

– Open Book Test: Evaluate based on the depth of analysis and application of concepts. Provide feedback on critical thinking and problem-solving skills.

End-Semester Examination (ESE)

End-Semester Examination (ESE) of 70 marks written theory examination based on all the unit of course syllabus scheduled by university. Question papers will be sent by the University through QPD (Question Paper Delivery). University will schedule and conduct ESE at the end of the semester.

• Format and Implementation:

1. **Question Paper Design:** Below structure is to be followed to design an End-Semester Examination (ESE) for a theory subject of 70 marks on all 5 units of the syllabus with questions set as per Bloom's Taxonomy guidelines and 14 marks allocated per unit.
2. **Balanced Coverage:** Ensure balanced coverage of all units with questions that assess different cognitive levels of Bloom's Taxonomy: Remember, Understand, Apply, Analyze, Evaluate, and Create. The questions should be structured to cover:
    - Remembering: Basic recall of facts and concepts.
    - Understanding: Explanation of ideas or concepts.
    - Applying: Use of information in new situations.
    - Analyzing: Drawing connections among ideas.
    - Evaluating: Justifying a decision or course of action.
    - Creating: Producing new or original work (if applicable).
3. **Detailed Scheme:** Unit-Wise Allocation (14 Marks per Unit): Each unit will have a combination of questions designed to assess different cognitive levels. By following this scheme, you can ensure a comprehensive and fair assessment of students' understanding and application of the course material, adhering to Bloom's Taxonomy guidelines for cognitive skills evaluation

Third Year Engineering (2024 Pattern) – Chemical Engineering

Level 5.5															
Course Code	Course Type	Course Name	Teaching Scheme (Hrs./week)			Examination Scheme and Marks						Credits			
			Theory	Tutorial	Practical	CCE	End-Sem	Term work	Practical	Oral	Total	Theory	Tutorial	Practical	Total
Semester V															
PCC-301-CEE	Program Core Course	Mass Transfer	3	-	-	30	70	-	-	-	100	3	-	-	3
PCC-302- CEE	Program Core Course	Reaction Engineering - I	3	-	-	30	70	-	-	-	100	3	-	-	3
PCC-303-CEE	Program Core Course	Chemical Technology & Equipment Design	3	-	-	30	70	-	-	-	100	3	-	-	3
PCC-304- CEE	Program Core Course	Mass Transfer Lab	-	-	4	-	-	50	25	-	75	-	-	2	2
PCC-305-CEE	Program Core Course	Computer Aided Chemical Engineering Lab	-	-	2	-	-	25	-	25	50	-	-	1	1
PEC-321-CEE	Program Elective Course	PEC – I	3	-	-	30	70	-	-	-	100	3	-	-	3
PEC-322-CEE	Program Elective Course Lab	PEC – I Lab	-	-	2	-	-	25	-	25	50	-	-	1	1
MDM-331-CEE	Multidisciplinary Minor	Sustainable Practices	-	2	2	-	-	25	-	-	25	-	2	1	3
OLE-341-CEE	Open Elective		2	-	-	15	35	-	-	-	50	2	-	-	2
ELC-342-CEE	Experiential Learning Course	Technical Seminar	-	-	2	-	-	25	-	25	50	-	-	1	1
Total			**14**	**02**	**12**	**135**	**315**	**150**	**25**	**75**	**700**	**14**	**2**	**06**	**22**

Program Elective – I

PEC-I (Theory)	PEC-I (Lab)	Course Name
PEC-321A-CEE	PEC-322A-CEE	Process Instrumentation and Control
PEC-321B-CEE	PEC-322B-CEE	Advanced Materials
PEC-321C-CEE	PEC-322C-CEE	Environmental Engineering

***Note**: Students can opt for Open Electives offered by different discipline/faculty like Law, Commerce and Management, Humanities or Inter-Disciplinary studies. Example - IPR and Cyber Laws, Sustainability Development, Digital Personal Data Protection, The Constitution of India, etc.

NEP 2020 Compliant Curriculum Structure

Third Year Engineering (2024 Pattern) – Chemical Engineering

Level 5.5															
Course Code	Course Type	Course Name	Teaching Scheme (Hrs./week)			Examination Scheme and Marks						Credits			
			Theory	Tutorial	Practical	CCE	End-Sem	Term work	Practical	Oral	Total	Theory	Tutorial	Practical	Total
Semester VI															
PCC-351-CEE	Program Core Course	Reaction Engineering-II	3	-	-	30	70	-	-	-	100	3	-	-	3
PCC-352-CEE	Program Core Course	Transport Phenomena	2	-	-	30	70	-	-	-	100	2	-	-	2
PCC-353-CEE	Program Core Course	Reaction Engineering Lab		-	4	-	-	25	25	-	50	-	-	2	2
PCC-354-CEE	Program Core Course	Chemical Technology & Equipment Design Lab	-	-	2	-	-	25	-	25	50	-	-	1	1
PEC-361-CEE	Program Elective Course	PEC – II	3	-	-	30	70	-	-	-	100	3	-	-	3
PEC-362-CEE	Program Elective Course	PEC – III	3	-	-	30	70	-	-	-	100	3	-	-	3
PEC-363-CEE	Program Elective Course Lab	PEC - III Lab	-	-	2	-	-	25	25	-	50	-	-	1	1
MDM-371-CEE	Multidisciplinary Minor	Applied Numerical Techniques	2	-	-	15	35	-	-		50	2	-	-	2
VSE-373-CEE	Vocational and Skill Enhancement Course	Solar Technology and Maintenance	-	-	2	-	-	25	-	25	50	-	-	1	1
ELC-381-CEE	Experimental Learning Course	Internship / OJT	-	-	8	-	-	25	-	25	50	-	-	4	4
Total			**13**	**00**	**18**	**135**	**315**	**125**	**50**	**75**	**700**	**13**	**00**	**09**	**22**

Program Elective – II

PEC-II (Theory)	Course Name
PEC-361A-CEE	Chemical Engineering Thermodynamics
PEC-361B-CEE	Energy Conservation in Process Industries
PEC-361C-CEE	AI Applications in Chemical Engineering

Program Elective – III

PEC-III (Theory)	PEC-III (Lab)	Course Name
PEC-362A-CEE	PEC-362A-CEE	Separation Technologies
PEC-362B-CEE	PEC-362B-CEE	Analytical Techniques
PEC-362C-CEE	PEC-362C-CEE	Computational Fluid Dynamics

NEP 2020 Compliant Curriculum Structure Third Year Engineering (2024 Pattern)

Chemical Engineering

Third Year Engineering

(With effect from Academic Year 2026-27)

SEMESTER - V

Savitribai Phule Pune University Third Year of Chemical Engineering (2024 Pattern) Course Code: PCC-301-CEE Course Name: Mass Transfer		
Teaching Scheme	**Credit**	**Examination Scheme**
Theory: 03 Hours/Week	**03**	**CCE: 30 Marks** **End-Semester: 70 Marks**

Prerequisite Courses, if any: Fundamental knowledge of Mathematics, Fluid Mechanics, Heat Transfer, Process Calculation, etc.

Course Objectives:

The objective of the course is to

1. To learn the fundamental concepts of mass transfer operations in the chemical industries.
2. To use mass transfer principles to understand the diffusion, distillation, absorption, adsorption, etc.
3. To design variety of heat exchange equipment and evaporators.
4. To provide the basic tools to expose students to heat transfer applications in industrial Processes.

Course Outcomes:

After successful completion of the course, learner will be able to:

CO1: Explain the basic principles of mass transfer, molecular diffusion, concentration gradients, and Fick's laws, and solve diffusion problems in gases, liquids, and solids.

CO2: Analyze interphase mass transfer mechanisms using film, penetration, and surface renewal theories, and determine individual and overall mass transfer coefficients for gas-liquid systems.

CO3: Apply gas-liquid equilibrium principles and mass transfer concepts to analyze and design gas absorption processes, including the calculation of packed tower performance using HTU–NTU methods.

CO4: Evaluate psychometric properties and perform design and performance calculations for humidification and cooling tower operations used in industrial applications.

CO5: Analyze drying characteristics of wet solids, interpret drying rate curves, and select suitable drying equipment for industrial drying operations.

Course Contents

Unit I	Fundamentals of Mass Transfer	(07 Hours)

General principles of Mass Transfer, Classification of Mass Transfer Operations, Choice of Separation method, Methods of conducting mass transfer, Design principles, Diffusion Mass Transfer, Molecular Diffusion in gases and liquids, Eddy diffusion, diffusivities of gases and liquids, Fick’s and Maxwell law of diffusion, diffusion in solids.

Unit II	Inter-Phase Mass Transfer	(07 Hours)

Mass transfer coefficients in laminar flow and turbulent flow, Local Mass Transfer Coefficient, Theories of mass transfer, Mass, heat and momentum transfer analogies. Inter-phase mass transfer, Overall Mass Transfer coefficient, Equilibrium in mass transfer. Continuous co-current, counter current and cross current processes, Stage and Cascade operation.

Unit III	Gas Absorption	(07 Hours)

Mechanism of gas absorption, equilibrium in gas absorption, application of mass transfer theories to absorption, absorption in wetted wall columns, values of transfer coefficient, absorption in packed tower and spray tower, calculation of HETP, HTU, NTU, calculations of height of packed and spray tower. Absorption in tray towers, absorption and stripping factors, tray efficiencies, calculation of number of trays for absorption, absorption with chemical reaction.

Unit IV	Humidification	(07 Hours)

Principles, vapour-liquid equilibria, enthalpy of pure substances, basic definition of all humidification terms, wet bulb temperature relation, psychrometric chart, Lewis relation, methods of humidification and dehumidification, equipment like cooling towers, tray towers, spray chambers, spray ponds, cooling tower design – HTU, NTU concept, calculation of height of cooling tower.

Unit V	Drying	(07 Hours)

Principles, equilibrium in drying, type of moisture binding, mechanism of batch drying, continuous drying, time required for drying, mechanism of moisture movement in solid, design principles of tray dryer, rotary dryer, drum dryer, spray dryer, fluidized bed and spouted bed dryer, pneumatic dryer and vacuum dryer.

Learning Resources

Reference Books:

1. Mass Transfer Operations – Treybal R.E., McGraw Hill
2. Chemical Engineering, Vol. I & II – Coulson J.M. and |Richardson J.F., McGraw Hill
3. Principles of Unit Operations in Chemical Engineering, Foust A.S.
4. Separation Techniques – King C.J. Design of Equilibrium Stage Processes - Smith B.D
5. McCabe and Smith, ‘Unit Operations in Chemical Engineering” 4. Henley E. J. and Seader
6. H.K. “Stage wise Process Design”, McGraw Hill
7. Smith B.D., “Design of Equilibrium Stage Process”.
8. Transport Processes and Separation Process Principles- Christie John Geankoplis Pearson

NPTEL Video Link

1. https://www.youtube.com/watch?v=Yc2eSffzhBI&list=PLwdnzlV3ogoVX_S_8DyKa7RudEazDL0o
2. https://www.youtube.com/watch?v=fMdKfuMmrjo
3. https://www.youtube.com/watch?v=3vilmUN9Qls
4. https://www.youtube.com/watch?v=8_6Crm6oWKA

5. https://www.youtube.com/watch?v=RNWsbrYzPXQ
6. https://www.youtube.com/watch?v=ue1vLeS7c7g

Savitribai Phule Pune University Second Year of Chemical Engineering (2024 Pattern) Course Code: PCC-302-CEE Course Name: Reaction Engineering -I		
Teaching Scheme	**Credit**	**Examination Scheme**
Theory: 03 Hours/Week	**03**	**CCE: 30 Marks** **End-Semester: 70 Marks**

Prerequisite Courses, if any: Chemistry, Process Calculations, Introduction to Chemical Engineers, Introduction to Computational Tools.

Course Objectives:

The objective of the course is to

1. To understand the fundamentals of homogeneous reaction kinetics.
2. To interpret experimental kinetic data and determine reaction parameters.
3. To study design and performance of ideal reactors.
4. To analyze and optimize reactor and product distribution
5. To introduce non-ideal flow behavior using Residence Time Distribution (RTD).

Course Outcomes:

After successful completion of the course, learner will be able to:

CO1: Explain the fundamentals of chemical kinetics and rate laws.

CO2: Analyze reaction rate data and determine kinetic parameters.

CO3: Apply design equations for ideal reactors such as batch, CSTR, and PFR.

CO4: Evaluate multiple reactions and product distribution.

CO5: Analyze non-ideal reactor behavior using RTD and modern computational tools.

Course Contents

Unit I	Fundamentals of Chemical Reaction Engineering	(06 Hours)

Introduction to chemical reaction engineering; classification of reactions; homogeneous and heterogeneous reactions; molecularity and order of reaction; elementary and non-elementary reactions reaction and rate expressions; temperature dependence of reaction rate; Arrhenius equation; activation energy; kinetic models for non-elementary reactions, searching mechanism, rate controlling step.

Unit II	Interpretation of Reaction Rate Data	(06 Hours)

Analysis of reaction rate data obtained from batch reactors; differential and integral methods of analysis; determination of reaction order and rate constants; half-life method.

Unit III	Ideal Reactors and Reactor Design	(06 Hours)

Design and performance of ideal reactors; batch reactor design equations; constant and variable volume batch reactors; continuous stirred tank reactor (CSTR); plug flow reactor (PFR); space time and space velocity; comparison of reactor performance; reactors in series and parallel.		
Unit IV	**Multiple Reactions and Reactor Optimization**	**(06 Hours)**
Types of multiple reactions including series, parallel, and complex reactions; selectivity, yield, and conversion; strategies for maximizing desired product; effect of reactor type and operating conditions on product distribution		
Unit V	**Non-Ideal Reactors and Residence Time Distribution (RTD)**	**(06 Hours)**
Introduction to non-ideal flow in reactors; causes of non-ideal flow behavior; residence time distribution concepts; RTD functions E(t) and F(t); experimental determination of RTD using tracer techniques; mean residence time and variance; RTD for ideal reactors (CSTR and PFR); models for non-ideal reactors such as dispersion model and tanks-in-series model.		

Learning Resources

Text Books:

1. Elements of Chemical Reaction Engineering: H. Scott, Fogler.
2. Chemical Reaction Engineering: Levenspiel O
3. Chemical Engineering Kinetics: Smith J.

Reference Books:

1. Chemical Reaction Engineering: Beyond the Fundamentals – L.K. Doraiswamy & Deniz Uner
2. Coulson and Richardson's Chemical Engineering Volume 3A

e-Books:

- **https://web.iitd.ac.in/~hirani/MEL311.pdf**

MOOC/NPTEL/YouTube Links:

1. **https://archive.nptel.ac.in/courses**
2. **https://onlinecourses.nptel.ac.in/noc21_ch33/preview?utm_source=chatgpt.com**

Savitribai Phule Pune University Second Year of Chemical Engineering (2024 Pattern) Course Code: PCC-303-CEE Course Name: Chemical Tech & Equipment Design		
Teaching Scheme	**Credit**	**Examination Scheme**
Theory: 03 Hours/Week	**03**	**CCE: 30 Marks** **End-Semester: 70 Marks**

Prerequisite Courses, if any: The students should know the basic engineering fundamentals such as material sciences, basic mathematics, momentum and heat transfer, stress- strain analysis and Reaction engineering fundamentals

Course Objectives:

1. The objective of the course is
2. To impart fundamentals of process equipment design
3. To develop understanding of process selection and technology
4. To introduce process flow diagrams and equipment layout
5. To provide knowledge of industrial chemical processes
6. To emphasize safety, environmental, and economic considerations

Course Outcomes:

After successful completion of the course, learner will be able to:

CO1: Apply fundamental design principles including corrosion prevention, stress analysis, and failure theories to the design of pressure vessels and high-pressure equipment.

CO2: Analyze and design reaction vessels and heat exchangers by selecting appropriate configurations, heating systems, and evaluating performance criteria.

CO3: Explain unit operations and processes involved in major inorganic industries such as chlor-alkali, cement, aluminum, and iron & steel production.

CO4: Describe the manufacturing processes, raw materials, and industrial applications of sulfur, nitrogen, sugar, starch, and phosphorus-based products.

CO5: Interpret production routes and process mechanisms for key petrochemicals derived from C-1, C-2, and C-3 compounds.

Course Contents

Unit I	Design Considerations, Pressure Vessels and High Pressure vessels	(06 Hours)

Basic Design Considerations: Corrosion, Corrosion Prevention, Protective Coatings, Linings for Chemical Plants and Equipment, Stresses created due to static and dynamic load, Design stress, Elastic Instability, Combined stresses and theories of failure.

Pressure Vessel: Operating Conditions, Pressure vessel code and selection of materials, Design Conditions and stresses, Design of Shell and its components, Illustration.

High Pressure vessel: Constructional features, Materials for High Pressure Vessels, Solid Walled Vessel, Multi-shell construction, Vessel closures, Illustration.

Unit II	**Reaction Vessels and Heat Exchangers**	**(06 Hours)**

Reaction Vessels: Classification of reaction vessels, Heating systems, design considerations of reaction vessel, Illustration.

Heat Exchangers: Types of Heat Exchangers, Design of Shell and Tube Heat Exchangers, Illustration

Unit III	**Unit operations, Processes and Inorganic Industry**	**(06 Hours)**

Introduction: Chemical industries-facts and figures, Unit operation and unit process concepts.

Chlor-Alkali Industries: Soda ash, Solvay process, dual process, Natural soda ash from deposits, Electrolytic process, Caustic soda. Production of Aluminum Oxide by Bayer's Process.

Cements: Introduction, types of cements, properties and applications. Manufacture of Portland cement. Beneficiation & Production of Hydrated lime.

Iron and Steel: Production of steel, blast furnace detail.

Unit IV	**Sulfur, Nitrogen, Sugar and Phosphorus Industry**	**(06 Hours)**

Sulfur Industries: Elemental sulfur mining by Frasch process, Sulfur production by oxidation-reduction of H_2S, Sulfuric acid by DCDA process. Nitrogen Industries: Ammonia, Nitric acid, Urea from ammonium carbonate, Ammonium Nitrate and Nitrolime. Sugar and Starch: Extraction of sugar cane to produce sugar, Starch production from maize. Phosphorus Industries: Phosphoric acid - Electric furnace process, HCl Leaching, Calcium phosphate, Ammonium phosphates.

Unit V	**Introduction to Petrochemical Industry**	**(06 Hours)**

C-1 Compounds: Production of Methanol, Formaldehyde, and Halogenated Hydrocarbons, Trichloroethylene, perchloroethylene. C-2 Compounds: Ethylene Dichloride, Vinyl Chloride via EDC, Vinyl chloride via acetylene-HCl reaction, Ethylene Oxide, Ethanolamines.

C-3 Compounds: Production of Isopropanol, Acetone, Cumene, Acrylonitrile, Propylene Oxide.

Learning Resources

Text Books:

1. V. V. Mahajani, S. B. Umarji, 2014, Joshi's Process Equipment Design, Trinity Press.
2. Sittig M. and Gopala Rao M., Dryden's Outlines of Chemical Technology for the 21st Century,

3rd Edition, WEP East West Press, 2010

Reference Books:

1. Austin G.T., Shreve's Chemical Process Industries - International Student Edition, 5th Edition, McGraw Hill Inc., 1998.
2. J. M. Coulson, J. F. Richardson, R. K. Sinott, 2005, Chemical Engineering Design Vol. 6, Pergamon Press.
3. Unit Processes in Organic Synthesis, Groggins P., McGraw Hill.

e-Books:

1. https://www.scribd.com/document/382802837/Joshi-s-Process-Equipment-Design
2. Dryden&#x27s Outlines of Chemical Technology - PDFCOFFEE.COM

MOOC/NPTEL/YouTube Links:

1. https://www.bing.com/videos/riverview/relatedvideo?q=coursera+on+Chemical+equipment+design&&mid=A910EE45006FF2F58860A910EE45006FF2F58860&churl=https%3a%2f%2fwww.youtube.com%2fchannel%2fUCY-ANi3wxkUSGhAel7T0TGw&FORM=VRDGAR
2. https://onlinecourses.nptel.ac.in/noc25_ch15/preview
3. https://www.bing.com/videos/riverview/relatedvideo?q=coursera+on+Chemical+Process+Technology&&mid=C3FC88B40776A17FCD09C3FC88B40776A17FCD09&churl=https%3a%2f%2fwww.youtube.com%2fchannel%2fUC640y4UvDAlya_WOj5U4pfA&mmscn=mtsc&aps=23&FORM=VMSOVR

Savitribai Phule Pune University
Third Year of Chemical Engineering (2024 Pattern)
Course Code: PCC-304-CEE **Course Name: Mass Transfer Lab**

Teaching Scheme	Credit	Examination Scheme
Practical: 04 Hour/Week	**02**	**Term Work: 50 Marks** **Practical: 25 Marks**

Prerequisite Courses, if any: Fundamental knowledge of Mathematics, Fluid Mechanics, Heat Transfer, Process Calculation, etc.

Course Objectives:

The objective of the course is to

1. To provide hands-on experience with fundamental mass transfer operations and laboratory equipment used in drying, diffusion, humidification, absorption, and related unit operations.
2. To develop the ability to analyze experimental data, evaluate mass transfer parameters, and interpret the performance of mass transfer equipment using engineering principles.

Course Outcomes:

After successful completion of the course, learner will be able to:

CO1: **Perform** mass transfer experiments and **determine** transport parameters such as drying rate, diffusion coefficient, mass transfer coefficient, relative humidity, and equipment efficiency using standard laboratory procedures.

CO2: **Analyze** the performance of mass transfer equipment by interpreting experimental results and comparing them with theoretical models to evaluate the effectiveness of various mass transfer operations.

List of Laboratory Experiments (Any 8 experiments from the given list)

Experiment 1: Tray Dryer – To study the drying of wet material and to plot the rate of drying curve.

Experiment 2: Rotary Dryer – To study the rotary dryer & to calculate the dryer efficiency.

Experiment 3: Spray Dryer – To perform Spray Drying.

Experiment 4: Fluidized Bed Dryer – To study the characteristics of Fluidized Bed Dryer

Experiment 5: Liquid Diffusion – To calculate the Diffusion Coefficient for a liquid –liquid system

Experiment 6: Winkelmann's method – To find the diffusion Coefficient of vapors in still air

Experiment 7: Wetted Wall Column – To find the mass transfer coefficient in a wetted wall Column

Experiment 8: Enhancement Factor – To study solid dissolution with coinstantaneous reaction and to compare the experimental enhancement factor for mass transfer predicted by boundary layer and film model.(Solid Dissolution)

Experiment 9: Humidifier and Dehumidifier – To study the Humidification and Dehumidification Operation and to determine the relative humidity.

Experiment 10: Absorption- To study absorption in Packed Bed.

Guidelines for Instructor's Manual

- The instructor's manual is to be developed as a hands-on resource and reference.
- Copy of Curriculum, Conduction & Assessment guide lines, List of Experiments to be attached.

Guidelines for Student's Lab Journal

The students Lab Journal should contain following related to every experiment –

1. Title of the experiment
2. Objective
3. Apparatus with their detailed specifications.
4. Brief theory related to the experiment.
5. Connection diagram /circuit diagram.
6. Observation table
7. Sample calculations for one/two reading.
8. Result tables
9. Graph and Conclusions.

Guidelines for Laboratory Conduction

- Completion of any eight experiments from the prescribed syllabus is mandatory.
- Use of open source software and recent version is to been courage.

Guidelines for Lab/TW Assessment

- Continuous assessment of laboratory work is to be done based on overall performance.
- Each lab assignment/experiment assessment will assign grade/marks based on parameters with appropriate weightage.
- Suggested parameters for overall assessment as well as each laboratory assignment include:
  - ✓ Timely completion.
  - ✓ Performance.
  - ✓ Punctuality and neatness.

Learning Resources

Reference Books:

9. Mass Transfer Operations – Treybal R.E., McGraw Hill
10. Chemical Engineering, Vol. I & II – Coulson J.M. and |Richardson J.F., McGraw Hill
11. Principles of Unit Operations in Chemical Engineering, Foust A.S.
12. Separation Techniques – King C.J. Design of Equilibrium Stage Processes - Smith B.D
13. McCabe and Smith, 'Unit Operations in Chemical Engineering" 4. Henley E. J. and Seader
14. H.K. "Stage wise Process Design", McGraw Hill
15. Smith B.D., "Design of Equilibrium Stage Process".
16. Transport Processes and Separation Process Principles- Christie John Geankoplis Pearson

NPTEL Video Link

7. https://www.youtube.com/watch?v=Yc2eSffzhBI&list=PLwdnzlV3ogoVX_S_8DyKa7RudEazDL0o
8. https://www.youtube.com/watch?v=fMdKfuMmrjo
9. https://www.youtube.com/watch?v=3vilmUN9Qls
10. https://www.youtube.com/watch?v=8_6Crm6oWKA
11. https://www.youtube.com/watch?v=RNWsbrYzPXQ
12. https://www.youtube.com/watch?v=ue1vLeS7c7g

Savitribai Phule Pune University
Second Year of Chemical Engineering (2024 Pattern)
Course Code: PCC-305-CEE
Course Name: Computer Aided Chemical Engineering Lab

Teaching Scheme	Credit	Examination Scheme
Practical: 02 Hour/Week	01	Term Work : 25 Marks Oral : 25 Marks

Prerequisite Courses, if any: Matrix Algebra, Numerical Methods

Course Objectives:

The objectives of the course are to:

1. Introduce to the students, the use of computer methods/programs to solve basic Chemical Engineering problems.
2. Study numerical methods and devise computer programs to solve the problems.
3. Enable students to use software like Excel, MATLAB, MATHCAD, etc.

Course Outcomes:

After successful completion of the course, learner will be able to:

CO1: Understand computer methods/programs to solve Chemical Engineering problems

CO2: Devise computer solutions for the systems involving Linear Algebraic Equations

CO3: Solve Non-Linear Algebraic Equations using computational methods

CO4: Use computer methods/programs to solve systems involving ODE-IVPs

CO5: Calculate thermodynamic properties using software like excel, MATLAB, MATHCAD

Course Contents

Unit I	Introduction to Computer Aided Chemical Engineering	(03 Hours)

Use of computers for solving Chemical Engineering problems. Introduction to computational software like Excel, MATLAB, Mathcad, Scilab, Python, etc. to solve problems in Chemical Engineering, Basic commands, solvers, functions in these software.

Unit II	Computer Solutions to Chemical Engineering linear Systems	(03 Hours)

Linear Processes/Systems in Chemical Engineering, Material and Energy Balances involving system of Linear Algebraic Equations, Solution methods for System involving system of Linear Algebraic Equations, Steady state Binary Flash, Steady state staged operations.

Unit III	Computer Solutions to Chemical Engineering linear Systems	(03 Hours)

Simple non-linear systems in Chemical engineering, Regula Falsi Method, Secant's method, Newton's method, Newton-Raphson method. System of Non-Linear Equations, Multivariate Solution methods.

Unit IV	Ordinary Differential Equations-Initial Value Problems and Its Computer Solutions	(03 Hours)

Formation of differential equations (component balance) using laws of conservations of mass, energy and momentum, Ordinary Differential Equations (ODEs)-IVPs, degree, order, Computer methods to solve ODE-IVPs: Eulers method, Taylor series method, Wien's method, Runge-Kutta methods.		
Unit V	**Estimation of Thermodynamic Properties using Computer programs**	**(03 Hours)**
Introduction to thermodynamic properties, Overview of Equations of state (EoS), Two Parameter/Three parameter equations of state. EoS to estimate thermodynamic properties like compressibility factor, molar volume and P-V-T relationships.		

List of Laboratory Experiments (Any 8 experiments from the given list)
Experiment 1: Plot of Fanning's friction factor vs Reynold's number: Calculation of pressure drop in a pipe for various diameters covering laminar, transient and turbulent regions.
Experiment 2: Calculation of Heat Transfer Coefficient of forced convection in a pipe flow for various diameters covering laminar, transient and turbulent flows.
Experiment 3: Construction of Pxy and Txy diagrams for binary system using EXCEL/MATLAB
Experiment 4: Solution of steady state binary flash (LAEs), by matrix methods using Excel/MATLAB/MATHCAD
Experiment 5: Solving system of Linear Algebraic Equations (LAEs) by matrix methods using Excel/MATLAB.
Experiment 6: Polynomial root finding by Newton Raphson method and Secant method using software programs
Experiment 7: Solution of Muti-component Flash Equations using Nonlinear solvers in Excel/MATLAB
Experiment 8: Numerical solution of transient flow temperature profile of fluid using Euler's Explicit method using EXCEL/MATLAB
Experiment 9: Approximate solutions of ordinary differential equations by Runge-Kutta algorithm and its application in chemical engineering
Experiment 10: Estimation of critical properties from group contribution method using software
Experiment 11: Estimation of properties from empirical correlations using software

Guidelines for Instructor's Manual

- The instructor's manual is to be developed as a hands-on resource and reference.
- Copy of Curriculum, Conduction & Assessment guide lines, List of Experiments to be attached.

Guidelines for Student's Lab Journal

The students Lab Journal should contain following related to every experiment –

1. Title of the experiment
2. Objective
3. Apparatus with their detailed specifications.
4. Brief theory related to the experiment.
5. Connection diagram /circuit diagram.
6. Observation table
7. Sample calculations for one/two reading.
8. Result tables
9. Graph and Conclusions.

Guidelines for Laboratory Conduction

- Completion of any eight experiments from the prescribed syllabus is mandatory.
- Use of open source software and recent version is encouraged.

Guidelines for Lab/TW Assessment

- Continuous assessment of laboratory work is to be done based on overall-performance.
- Each lab assignment/experiment assessment will assign grade/marks based on parameters with appropriate weightage.
- Suggested parameters for overall assessment as well as each laboratory assignment include:
    - ✓ Timely completion.
    - ✓ Performance.
    - ✓ Punctuality and neatness.

Learning Resources

Text Books:

1. Law V. J., "Numerical Methods for Chemical Engineers using Excel, VBA, and MATLAB", CRC Press
2. Davis M. E., "Numerical Methods and Modeling for Chemical Engineers", Wiley, New York, 1984.
3. Ray A. K., Gupta S. K., "Mathematical Methods in Chemical and Environmental Engineering", International Thomson Learning, Singapore
4. Franks R.E.G., "Modeling and Simulation in Chemical Engineering", Wiley Inter-science, NY
5. Luyben W. L., "Process Modeling Simulation and Control for Chemical Engineers", McGraw Hill, 1988.

Reference Books:

1. John Ingam, Irving J. Dunn., "Chemical Engineering Dynamic Modeling with PC Simulation", VCH Publishers.
2. Kayode Coker A., "Chemical Process Design, Analysis and Simulation", Gulf Publishing Company.
3. Chapra S. C., Canale "R. P. Numerical Methods for Engineers", Tata McGraw-Hill, New Delhi

e-Resources:

1. https://www.mathworks.com/solutions/chemical-engineering.html
2. https://web.stanford.edu/~wfsharpe/mia/mat/mia_mat4.htm
3. http://courses.washington.edu/dtsclass/Matlab_Guide_v2.pdf
4. Numerical Methods Applied to Chemical Engineering | Chemical Engineering | MIT OpenCourseWare

MOOC/NPTEL/YouTube Links:

1. nptel.ac.in/courses/103105220
2. nptel.ac.in/courses/127106019
3. https://onlinecourses.nptel.ac.in/noc20_ge20/preview
4. https://nptel.ac.in/courses/103102352

Savitribai Phule Pune University Second Year of Chemical Engineering (2024 Pattern) Course Code: PCC-321A-CEE Course Name: Process Instrumentation and Control		
Teaching Scheme	**Credit**	**Examination Scheme**
Theory: 03 Hours/Week	**03**	**CCE: 30 Marks** **End-Semester: 70 Marks**

Prerequisites: Mathematics, Basics of Chemical Engineering

Course Objectives:

1. Understand process instruments and their characteristics.
2. Perform dynamic mathematical modelling of simple chemical processes.
3. Understand design concepts of feedback control loop.
4. Perform stability analysis and frequency response of control systems.
5. Understand the design of complex control schemes and digital control.

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

CO1: Identify appropriate instruments for process variables measurement.
CO2: Develop dynamic mathematical models for simple chemical processes.
CO3: Design single-loop feedback control systems.
CO4: Analyze stability of systems and tune controllers appropriately.
CO5: Design complex control schemes and digital control systems.

Course Contents:

Unit I	Introduction to Process Instrumentation	8 Hours

Introduction: Elements of measurement, static and dynamic characteristics of instruments, signal conditioning concepts
Temperature Measurement: Expansion thermometers, Resistance thermometers (RTDs), thermocouples, and pyrometers.
Pressure Measurement: Strain gauges, Bourdon tubes, and capacitive transducers.
Flow Measurement: Orifice meter, venturi-meter, rotameter and electrical flow measuring devices.
Level Measurement: Level measurement by direct method, electrical level measuring devices.
Composition Measurement: Basic composition measurement methods.

Unit II	Dynamic Behavior of Simple Chemical Processes	8 Hours

Mathematical modelling of processes: Process variables, Types of inputs, Types of systems
First order processes: Liquid level in tank, Thermometer, isothermal and non-isothermal CSTR, Dynamic response of first order system to impulse and step inputs, dead-time systems, pure capacity system
Second order processes: Interacting and Non-interacting systems, Step response of second order system, Characteristics of under-damped system
Linearization of nonlinear systems: Liquid level system, non-isothermal CSTR system
Laplace Transforms: Laplace transforms of basic functions, Transfer function of simple processes

Unit III	Design of Single-Loop Feedback Control Systems	8 Hours

Feedback Control Loop: Objectives of Chemical Process Control, Elements of feedback control loop, loop transfer function, Servo & Regulatory problem
Classical controllers: P, PI, PID and On-off controllers
Dynamic Behaviour of feed-back control processes

Unit IV	Stability Analysis and Frequency Response	8 Hours

Stability Criteria: Characteristic equation, Poles-zeros in complex plane, Routh-Hurwitz stability criterion and Root Locus analysis. **Controller Error Performance Criteria:** One-quarter decay ratio, Time Integral performance criteria by ISE, IAE, ITAE **Frequency Response:** Introduction to Bode plots, Nyquist plots and stability in frequency domain. **Controller Tuning:** Cohen-Coon and Ziegler-Nichols techniques.		
Unit V	**Design of Complex Control Schemes and Digital Control**	**8 Hours**
Design of complex control schemes: Control schemes for large time-delay systems, inverse-response systems, cascade control, selective control, split range control, feed forward, ratio, adaptive and inferential control systems **Fundamentals of digital control:** Conversion of continuous to discrete signals and vice versa, Digital approximation of classical controllers **Digital Control Systems:** Introduction to Distributed Control Systems (DCS), Programmable Logic Controllers (PLC), and SCADA architecture.		
Textbooks: 1. Chemical Process Control, George Stephanopoulos, Englewood Cliffs, NJ: Prentice hall 2. Process System Analysis & Control, Donald R. Coughanour, Mc Graw Hill Publishing		
Reference Books: 1. Instrument Engineers Handbook (Process Control) –Bella G. Liptak, Elsevier 2. Instrumentation and Control, Patranabis D. PHI Learning Publication 3. Process Control: Modelling, Design & Control, B. Wayne Bequette, PHI Publication 4. Process Dynamics & Control, Dale E. Seaborg, Thomal F. Edgar, Dancan A. Mellichamp, Wiley Publications		
MOOC / NPTEL Courses: 1. https://onlinecourses.nptel.ac.in/noc21_ch38/preview 2. https://nptel.ac.in/courses/103105064		

Savitribai Phule Pune University Second Year of Chemical Engineering (2024 Pattern) Course Code: PCC-321B-CEE Course Name: Advanced Materials (Elective)		
Teaching Scheme	**Credit**	**Examination Scheme**
Theory: 03 Hours/Week	**03**	**CCE: 30 Marks** **End-Semester: 70 Marks**

Prerequisite Courses, if any:

Course Objectives:

1. The objective of the course is to o introduce the fundamental concepts of Material Science.
2. To develop an understanding of material selection based on their properties for various engineering applications.
3. To study different methods used for testing and evaluation of materials.
4. To explore applications of advanced materials such as nanomaterials.

Course Outcomes:

After successful completion of the course, learner will be able to:

CO1: Explain the scope of engineering materials, their properties, and criteria for material selection for engineering applications.

CO2: Perform standard tests on different engineering materials and classify organic materials based on their characteristics.

CO3: Define corrosion, classify its types, and explain methods for corrosion control and prevention.

CO4: Describe polymers, compare types of polymerization processes, and classify plastics and rubbers based on properties.

CO5: Evaluate the internal properties of engineering materials using appropriate testing techniques. *(Evaluate)*

Course Contents

Unit I	**Introduction**	**(06 Hours)**

Scope of engineering materials. Definition and explanation of key material properties, including melting point, boiling point, specific heat, thermal conductivity, thermal expansion, thermal insulation, stress, strain, yield stress, fatigue, and creep.

Unit II	**Testing of engineering materials**	**(06 Hours)**

Classification of tests into destructive and non-destructive testing methods. Structure of atom and types of chemical bonds. Crystal structures and their influence on material properties. Deformation mechanisms and slip processes in materials.

Unit III	**Polymers**	**(06 Hours)**

Iron – Carbon diagram high and low temperature material, insulation, refractories.
Definition and importance of Polymer Addition and condensation Polymerization Plastics: definition, classification, general properties and uses Rubbers: definition, classification, general properties and uses Compare natural and synthetic rubber Vulcanizing of rubber

Unit IV	**Nanomaterial's**	**(06 Hours)**

Classification of nanomaterial's. Methods of synthesis and characterization of nanomaterials. Types and applications of nanomaterials such as fullerenes, buckyballs, and carbon nanotubes. Study of nanoparticles with special reference to silver nanoparticles. Applications of nanomaterials in the chemical industry.

Unit V	Analytical Techniques	(06 Hours)

Electron Microscopes; scanning electron microscopy (Basics, Principal Elements, working), transmission electron microscopy (Basics, Principal Elements, working). Scanning probe microscopes; scanning tunneling microscopy, atomic force microscopy, other kinds of microscopes; X-ray diffraction.

List of Laboratory Experiments (Any 8 experiments from the given list)

Experiment 1: Study of properties of polymeric materials and testing of polymers; synthesis of polymers such as Nylon, PVC, PTFE, etc.

Experiment 2: Determination of hardness of metals using different methods: Rockwell Hardness Test, Brinell Hardness Test, and Shore Scleroscope Test.

Experiment 3:Determination of impact strength of materials using Izod and Charpy impact tests on mild steel, copper, brass, and aluminum specimens.

Experiment 4: Chemical analysis of metals and alloys for estimation of a specific element (e.g., carbon in steel, copper in brass, molybdenum in stainless steel, etc.).

Experiment 5:Study of testing and treatment methods including:

i) Dye penetrant test

ii) Rubber lining process

iii) Ultrasonic testing

iv) Heat treatment processes

Experiment 6: Study of nanomaterial and their synthesis methods.

Experiment 7: Study of moisture adsorption behavior of nanomaterials.

Experiment 8: Study of the effect of temperature and relative humidity on nanomaterials.

Experiment 9: Synthesis of gold/silver (Au/Ag) nanoparticles and recording of optical absorption spectra using a simple absorption spectrometer.

Experiment 10: Synthesis of zinc oxide (ZnO) nanoparticles by chemical route and determination of particle size using UV–Visible absorption spectroscopy.

Experiment 11: Synthesis of titanium dioxide (TiO_2) nanoparticles by chemical route and determination of phase and particle size using X-ray diffraction (XRD) and Scherrer equation.

Guidelines for Student's Lab Journal

The students Lab Journal should contain following points for each experiment –

1. Title of the experiment
2. Objective

3. Apparatus with their detailed specifications.
4. Brief theory related to the experiment.
5. Connection diagram /circuit diagram.
6. Observation table
7. Sample calculations for one/two reading.
8. Result tables
9. Graph and Conclusions.

Guidelines for Laboratory Conduction

- Completion of any eight experiments from the prescribed syllabus is mandatory. .
- Use of open source software and recent version is to been courage.

Guidelines for Lab/TW Assessment

- Continuous assessment of laboratory work is to be done based on overall -performance.
- Each lab assignment/experiment assessment will assign grade/marks based on parameters with appropriate weightage.
- Suggested parameters for overall assessment as well as each laboratory assignment include:
  - ✓ Timely completion.
  - ✓ Performance.
  - ✓ Punctuality and neatness.

Learning Resources

Text Books:

1. James F. Shacketford, introduction to material science, McMillan publishing company, New
2. York ISBN 1990.
3. D.Z. Jestrazebaski, properties of Engg. Materials, 3rd Ed. Toppers. Co. Ltd.
4. J.L. Lee and Evans, Selecting Engineering materials for chemical and process plants,
5. Business Works 1978.
5. A text book of machine design, Khurmi R.S. and Gupta J.K.
6. Introduction to Nano Technology, John Wiley & Sons by Charles P Poole, Frank J Owens.
6. William D. Callister, David G. Rethwisch Materials Science and Engineering: An Introduction, Wiley Publisher.
7. B. S. Mitchell An Introduction to Materials Engineering and Science for Chemical and Materials Engineers, John Wiley & Sons, 2004.

Reference Books:

1. Nano materials, synthesis, properties and applications, Institute of physics publishing,
2. Bristol and Philadelphia, by A.S. Edelstein and R.C. Kamarhati
3. R. A. L Jones, Soft Condensed Matter, Oxford University Press, 2002.

e-Books:

1. https://web.iitd.ac.in/~hirani/MEL311.pdf
2. https://www.me.iitb.ac.in/~ramesh/courses/ME423/shafts.pdf

3. https://etcfunsafe.com/downloads/PVI-STUDY-NOTES-ENGLISH-TRIAL.pdf

MOOC/NPTEL/YouTube Links:

1. https://archive.nptel.ac.in/courses/112/105/112105125/

Savitribai Phule Pune University

Second Year of Chemical Engineering (2024 Pattern)

Course Code: PCC-321C-CEE **Course Name: Environmental Engineering**

Teaching Scheme	Credit	Examination Scheme
Theory: 03 Hours/Week	**03**	**CCE: 30 Marks** **End-Semester: 70 Marks**

Prerequisite Courses, if any:

Course Objectives:

The objective of the course is to:

1. Understand the fundamental concepts of environmental engineering and the impact of human activities on the environment.
2. Study the sources, effects, measurement, and control of air pollution and associated environmental regulations.
3. Understand the characteristics of wastewater and the principles of water pollution prevention and control.
4. Learn the design principles and operational aspects of conventional and advanced wastewater treatment technologies.
5. Develop knowledge of tertiary treatment processes, solid waste management, and sustainable environmental protection practices.

Course Outcomes:

After successful completion of the course, learner will be able to:

CO1: Explain the principles of environmental engineering, environmental pollution, relevant regulations, and the impact of human activities on the environment.

CO2: Analyze sources, effects, measurement techniques, and control strategies for air pollutants and evaluate the performance of air pollution control equipment.

CO3: Assess water pollution problems by analyzing wastewater characteristics and interpreting water quality standards.

CO4: Apply the principles of conventional and advanced wastewater treatment processes for environmental protection.

CO5: Evaluate tertiary treatment technologies and solid waste management practices for sustainable environmental management.

Course Contents

Unit I	Introduction to Environmental Engineering and Air Pollution	(07 Hours)

Overview of environmental engineering, Environmental pollution: air, water, and soil pollution, Impact of population growth on the environment. Environmental impacts of thermal, hydro, and nuclear energy generation. Chemical pollution and solid waste generation. Prevention and control of environmental pollution. Environmental laws, regulations, and standards. Clean Development Mechanism (CDM) and Kyoto Protocol. Definition, sources, classification, and scales of concentration of air pollutants. Effects of air pollutants on human health, plants, animals, materials, and economy. Air quality standards: WHO, BIS, MPCB, and CPCB.

Unit II	Air Pollution Control Methods and Equipment	(07 Hours)

Particulate pollution and collection efficiency. Particulate collection systems: Settling chamber, Cyclone separator, Fabric filter, Electrostatic precipitator.

Wet collection devices: Spray tower, Centrifugal scrubber, Venturi scrubber. Selection of particulate collectors.

Gaseous pollution control: Absorption, Adsorption, Combustion and catalytic oxidation. Control of SOx and NOx emissions. Numerical problems based on air pollution control equipment.

Unit III	Water Pollution and Wastewater Characteristics	(07 Hours)

Domestic and industrial wastewater. Sources, types, and effects of water pollutants.

Wastewater characteristics: Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Organic Carbon (TOC), Total Suspended Solids (TSS), Colour and odour, Bacteriological quality. Oxygen deficit and determination of BOD constants. Water quality standards: ICMR, WHO, MPCB, and CPCB.

Unit IV	Wastewater Treatment Technologies	(07 Hours)

Principles of primary and secondary wastewater treatment. Activated sludge process (suspended growth systems): design considerations and operation, Sludge treatment and disposal, Trickling filters,Moving Bed Biofilm Reactor (MBBR).

Advanced wastewater treatment methods: Up flow Anaerobic Sludge Blanket (UASB), Photocatalytic reactors, Wet-air oxidation, Membrane Bioreactor (MBR), Biosorption.

Unit V	Tertiary Treatment and Solid Waste Management	(07 Hours)

Tertiary wastewater treatment: Disinfection using chlorine, ozone, hydrogen peroxide, and UV radiation, Recovery of materials from process effluents, Micro-screening, Biological nitrification and denitrification, Granular medium filtration.

Land pollution and solid waste management: Sources and classification of solid wastes, Collection, segregation, and transportation, Disposal methods, Incineration, Composting, Recovery and recycling of solid waste.

Sustainable waste management practices and circular economy concepts.

Learning Resources

Text Books:

1. Rao C. S. "Environmental Pollution Control Engineering", Wiley Eastern Publications.
2. Mahajan S.P. "Pollution Control in Process Industry", Tata McGraw Hill Publishers
3. G. Kiely, Environmental Engineering, McGraw Hill 1997.

Reference Books:

1. Metcalf and Eddy "Wastewater Engineering", Tata McGraw Hill Publishers.
2. J.C. Mycock, John D. McKenna, Louis Theodore "Handbook of Air Pollution Control Engineering and Technology".
3. Flagan R.C. and Seinfield J.H. "Fundamentals of Air Pollution Engineering" Prentice- Hall, Inc., Englewood Cliffs, New Jersey.
4. Peavy H.S. and Rowe D.R. and Tchobanoglous G. "Environmental Engineering" McGraw-Hil International Ed., 1985,

5. Martin Crowford “Air Pollution Control theory” McGraw-Hill Inc.,US.
6. Stern “Air Pollution”, Vol.-I and Vol.-II, 2nd Edition, Academic Press, New York.

e-Books:

1. **Principal of Environmental Engineering** : https://link.springer.com/book/10.1007/978-981-16-9431-8
2. **Pollution prevention and control:** https://bookboon.com/en/pollution-prevention-and-control-ebook
3. **Basic of Environmental Engineering:** https://soaneemrana.org/onewebmedia/Basic%20Environmental%20Engineering%20by%20R.C%20gaur.pdf
4. **Environmental Engineering:** https://static.pw.live/5eb393ee95fab7468a79d189/GLOBAL_CMS_BLOGS/a6525ae5-0247-42cd-8f03-a4894adec409.pdf

MOOC/NPTEL/YouTube Links:

1. https://www.youtube.com/watch?v=0aXP5qnihns
2. https://www.youtube.com/watch?v=h0zaOWU0JKc

Savitribai Phule Pune University
Second Year of Chemical Engineering (2024 Pattern)

Course Code: PCC-322A-CEE **Course Name: Instrumentation and Process Control Lab**

Teaching Scheme (Hrs/Week)	Credit	Evaluation Scheme
Practical: 02 Hours/Week	01	Term Work: 25 Marks Oral: 25 Marks

Prerequisites: Mathematics, Numerical methods, Basics of Chemical Engineering

Course Objectives:

1. Understand working of process instruments
2. Understand the dynamic behavior of simple chemical processes
3. Design controller for simple processes
4. Understand stability analysis of simple processes
5. Understand feedback control loop simulation

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

CO1: Evaluate calibration of process instruments and understand their working

CO2: Analyze dynamic behavior of simple chemical processes through their response

CO3: Analyze controller performance for simple processes

CO4: Evaluate stability analysis of simple processes

CO5: Evaluate feedback control loop simulation

List of Experiments (minimum 8 must be performed)

Experiment 1: Calibration of bimetallic thermometer

Experiment 2: Calibration of rotameter

Experiment 3: Dynamic response of liquid level in tank system

Experiment 4: Dynamic response of two tank interacting systems

Experiment 5: Dynamic response of two tank non-interacting systems

Experiment 6: Dynamic response of an on-off controller

Experiment 7: Dynamic response of P, PI and PID controllers

Experiment 8: Root locus analysis

Experiment 9: Root locus analysis on software (Ex. MATLAB)

Experiment 10: Bode plot on software (Ex. MATLAB)

Experiment 11: PID control loop simulation for a first order process (Ex. SIMULINK)

Virtual Laboratories:

1. Characterize temperature sensor: https://sl-coep.vlabs.ac.in/exp/characterize-temperature-sensor/
2. Calibrate pH sensor: https://sl-coep.vlabs.ac.in/exp/performance-chemical-sensor/
3. Dynamic response of Stirred Tank Heater: https://cpd-iitkgp.vlabs.ac.in/exp/stirred-tank-heater/
4. Dynamic response of CSTR: https://cpd-iitkgp.vlabs.ac.in/exp/continuous-stirred-tank-reactor/

Savitribai Phule Pune University Second Year of Chemical Engineering (2024 Pattern) Course Code: PCC-322B-CEE Course Name: Advanced Materials Lab		
Teaching Scheme	**Credit**	**Examination Scheme**
Practical: 02 Hours/Week	**01**	**Term Work: 25 Marks** **Oral: 25 Marks**

Prerequisite Courses, if any:

Course Objectives:

The objective of the course is to-

1. The objective of the course is to introduce the fundamental concepts of Material Science.
2. To develop an understanding of material selection based on their properties for various engineering applications.
3. To study different methods used for testing and evaluation of materials.
4. To explore applications of advanced materials such as nanomaterials.

Course Outcomes:

After successful completion of the course, learner will be able to:

CO1: Explain the scope of engineering materials, their properties, and criteria for material selection for engineering applications.

CO2: Perform standard tests on different engineering materials and classify organic materials based on their characteristics.

CO3: Define corrosion, classify its types, and explain methods for corrosion control and prevention.

CO4: Describe polymers, compare types of polymerization processes, and classify plastics and rubbers based on properties.

CO5: Evaluate the internal properties of engineering materials using appropriate testing techniques.

Course Contents

List of Laboratory Experiments (Any 8 experiments from the given list)

Experiment 1: Study of properties of polymeric materials and testing of polymers; synthesis of polymers such as Nylon, PVC, PTFE, etc.

Experiment 2: Determination of hardness of metals using different methods: Rockwell Hardness Test, Brinell Hardness Test, and Shore Scleroscope Test.

Experiment 3: Determination of impact strength of materials using Izod and Charpy impact tests on mild steel, copper, brass, and aluminum specimens.

Experiment 4: Chemical analysis of metals and alloys for estimation of a specific element (e.g., carbon in steel, copper in brass, molybdenum in stainless steel, etc.).

Experiment 5: Study of testing and treatment methods including:

i) Dye penetrant test

ii) Rubber lining process

iii) Ultrasonic testing

iv) Heat treatment processes

Experiment 6: Study of nanomaterials and their synthesis methods.

Experiment 7: Study of moisture adsorption behavior of nanomaterials.

Experiment 8: Study of the effect of temperature and relative humidity on nanomaterials.

Experiment 9: Synthesis of gold/silver (Au/Ag) nanoparticles and recording of optical absorption spectra using a simple absorption spectrometer.

Experiment 10: Synthesis of zinc oxide (ZnO) nanoparticles by chemical route and determination of particle size using UV–Visible absorption spectroscopy.

Experiment 11: Synthesis of titanium dioxide (TiO_2) nanoparticles by chemical route and determination of phase and particle size using X-ray diffraction (XRD) and Scherrer equation.

Guidelines for Instructor's Manual

- The instructor's manual is to be developed as a hands-on resource and reference.
- Copy of Curriculum, Conduction & Assessment guide lines, List of Experiments to be attached.

Guidelines for Student's Lab Journal

The students Lab Journal should contain following related to every experiment –

1. Title of the experiment
2. Objective
3. Apparatus with their detailed specifications.
4. Brief theory related to the experiment.
5. Connection diagram /circuit diagram.
6. Observation table
7. Sample calculations for one/two reading.
8. Result tables
9. Graph and Conclusions.

Guidelines for Laboratory Conduction

- Completion of any eight experiments from the prescribed syllabus is mandatory.
- Use of open source software and recent version is to be encouraged.

Guidelines for Lab/TW Assessment

- Continuous assessment of laboratory work is to be done based on overall performance.
- Each lab assignment/experiment assessment will assign grade/marks based on parameters with appropriate weightage.
- Suggested parameters for overall assessment as well as each laboratory assignment include:
  - ✓ Timely completion.
  - ✓ Performance.
  - ✓ Punctuality and neatness.

Learning Resources

Reference Books:

1. James F. Shacketford, introduction to material science, McMillan publishing company, New York ISBN 1990.
2. D.Z. Jestrazebaski, properties of Engg. Materials, 3rd Ed. Toppers. Co. Ltd.
3. J.L. Lee and Evans, Selecting Engineering materials for chemical and process plants, Business Works 1978.
4. A text book of machine design, Khurmi R.S. and Gupta J.K.
5. Introduction to Nano Technology, John Wiley & Sons by Charles P Poole, Frank J Owens.
6. Nano materials, synthesis, properties and applications, Institute of physics publishing, Bristol and Philadelphia, by A.S. Edelstein and R.C. Kamarhati
7. R. A. L Jones, Soft Condensed Matter, Oxford University Press, 2002.
8. William D. Callister, David G. Rethwisch Materials Science and Engineering: An Introduction, Wiley Publisher.
9. B. S. Mitchell An Introduction to Materials Engineering and Science for Chemical and Materials Engineers, John Wiley & Sons, 2004.

Savitribai Phule Pune University Second Year of Chemical Engineering (2024 Pattern) Course Code: PCC-322C-CEE Course Name: Environmental Engineering Lab		
Teaching Scheme	**Credit**	**Examination Scheme**
Practical: 02 Hours/Week	**01**	**Term Work: 25 Marks** **Oral: 25 Marks**

Prerequisite Courses, if any:

Course Objectives:

The objective of the course is to-

1. Develop practical skills in the analysis and monitoring of water, wastewater, air, and solid waste quality parameters using standard laboratory methods.
2. Understand the principles and performance evaluation of environmental pollution control and treatment processes.
3. Interpret environmental data and assess compliance with environmental quality standards.

Course Outcomes:

After successful completion of the course, learner will be able to:

CO1: Perform laboratory analyses of environmental samples using standard procedures and instruments.

CO2: Analyze and interpret environmental quality parameters and compare them with prescribed standards.

CO3: Evaluate the effectiveness of pollution control and treatment processes and prepare technical reports based on experimental observations.

Course Contents

List of Laboratory Experiments (Any 8 experiments from the given list)

Experiment 1: Determination of pH of Water and Wastewater Samples
Experiment 2: Determination of Turbidity of Water Sample
Experiment 3: Determination of Total Solids (TS), Total Dissolved Solids (TDS), and Total Suspended Solids (TSS)
Experiment 4: Determination of Dissolved Oxygen (DO)
Experiment 5: Determination of Biochemical Oxygen Demand (BOD)
Experiment 6: Determination of Chemical Oxygen Demand (COD)
Experiment 7: Determination of Alkalinity of Water Sample
Experiment 8: Determination of Hardness of Water
Experiment 9: Determination of Chlorides in Water Sample
Experiment 10: Determination of Sulphates and Nitrates in Water Sample
Experiment 11: Determination of Air Quality Parameters
Experiment 12: Study of Activated Sludge Process (Demonstration/Model)
Experiment 13: Determination of Moisture Content and Organic Matter in Solid Waste

Experiment 14: Noise Level Measurement
Experiment 15: Field Visit and Environmental Audit Report

Guidelines for Instructor's Manual

- The instructor's manual is to be developed as a hands-on resource and reference.
- Copy of Curriculum, Conduction & Assessment guide lines, List of Experiments to be attached.

Guidelines for Student's Lab Journal

The students Lab Journal should contain following related to every experiment –

1. Title of the experiment
2. Objective
3. Apparatus with their detailed specifications.
4. Brief theory related to the experiment.
5. Connection diagram /circuit diagram.
6. Observation table
7. Sample calculations for one/two reading.
8. Result tables
9. Graph and Conclusions.

Guidelines for Laboratory Conduction

• Completion of any eight experiments from the prescribed syllabus is mandatory.
• Use of open source software and recent version is to be encouraged.

Guidelines for Lab/TW Assessment

- Continuous assessment of laboratory work is to be done based on overall performance.
- Each lab assignment/experiment assessment will assign grade/marks based on parameters with appropriate weightage.
- Suggested parameters for overall assessment as well as each laboratory assignment include:
  - ✓ Timely completion.
  - ✓ Performance.
  - ✓ Punctuality and neatness.

Learning Resources

Reference Books:

1. **Sawyer, C. N., McCarty, P. L., & Parkin, G. F. (2003).**
   Chemistry for Environmental Engineering and Science (5th Edition). McGraw-Hill Education.
   Comprehensive reference for water and wastewater quality analysis, DO, BOD, COD, alkalinity, hardness, and other laboratory experiments.
2. **APHA, AWWA, & WEF (2023).**
   Standard Methods for the Examination of Water and Wastewater (24th Edition). American Public Health Association, Washington, D.C.
   Standard laboratory procedures for water and wastewater analysis.
3. **Peavy, H. S., Rowe, D. R., & Tchobanoglous, G. (1985).**
   Environmental Engineering. McGraw-Hill.
   Covers environmental monitoring, pollution control, and treatment processes.

4. **Metcalf & Eddy, Inc. (2014).**
Wastewater Engineering: Treatment and Resource Recovery (5th Edition). McGraw-Hill Education.

Savitribai Phule Pune University Third Year of Chemical Engineering (2024 Pattern) Course Code: MDM-331-CEE Course Name: Sustainable Practices		
Teaching Scheme	**Credit**	**Examination Scheme**
Tutorial: 02 Hours/Week Practical: 02 Hours/Week	**03**	**TW: 25 Marks Oral: 25 Marks**

Prerequisite Courses, if any: Basic Knowledge of - energy resources, Iinterdisciplinary thinking, Environmental Studies, Eentrepreneurship

Course Objectives:

The course aims to enable students to

1. Understand the concepts, principles, and importance of sustainable development along with environmental, social, and economic dimensions of sustainability.
2. Develop awareness about global environmental challenges, natural resource conservation, pollution control, and sustainable solutions for environmental protection.
3. Apply sustainable practices, circular economy concepts, waste management approaches, and renewable energy technologies in engineering, industries, and society.
4. Interpret Sustainable Development Goals (SDGs), ESG, CSR, environmental ethics, and government sustainability initiatives to promote responsible and sustainable development.

Course Outcomes:

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

CO1: Explain the concept, principles, and importance of sustainable development along with major global environmental challenges and sustainability indicators.

CO2: Analyse natural resource conservation methods, pollution control measures, waste management practices, and environmental regulations for sustainable resource utilization.

CO3: Apply concepts of circular economy, sustainable practices, and industrial ecology for improving environmental and resource efficiency in society and industry.

CO4: Interpret Sustainable Development Goals (SDGs), ESG, CSR, and government sustainability initiatives to evaluate sustainable development strategies and innovations.

Course Contents

Unit I	**Introduction to Sustainable Development**	**(6 Hours)**

Concept and need of sustainable development, Pillars of sustainability: Environmental, Social, and Economic dimensions, Sustainable development principles and indicators, Global environmental issues and challenges, Climate change, global warming, and greenhouse effect, Ozone layer depletion and carbon footprint, Environmental ethics and sustainable lifestyles

Unit II	**Resources Protection and Conservation**	**(6 Hours)**

Natural resources and their conservation, Water resources and sustainable water management, Air, water, soil, and noise pollution, Pollution prevention and control measures, Waste minimization and 3R concepts: Reduce, Reuse, Recycle, Environmental laws and regulations, Environmental Impact Assessment (EIA)

Unit III	**Sustainable Practices and Circular Economy**	**(6 Hours)**

Sustainable agriculture and food systems, Sustainable transportation systems, Circular economy: Concept and importance, Linear economy vs circular economy, Resource recovery and waste management, Industrial ecology and industrial symbiosis, Sustainable consumption and production patterns

Unit IV	Sustainable Development Goals and Future Perspectives	(06 Hours)

Millennium Development Goals (MDGs), Sustainable Development Goals (SDGs), ESG (Environmental, Social, Governance) concepts, Corporate social responsibility (CSR) , Green entrepreneurship and sustainable innovation, Government initiatives and policies for sustainability, India's sustainable development initiatives and case studies

Tutorials: The students have to **complete at least 8 tutorials** from the following list.

T1: Study the concept and need of sustainable development with suitable real-life examples.

T2: Compare the environmental, social, and economic pillars of sustainability using a case study.

T3: Prepare a report on climate change, global warming, and greenhouse gas emissions in India.

T4: Calculate personal or institutional carbon footprint and suggest methods for reduction.

T5: Study ozone layer depletion causes, effects, and international protection measures.

T6: Analyse sustainable water management techniques such as rainwater harvesting and wastewater recycling.

T7: Conduct a survey on air, water, soil, or noise pollution in the local area and suggest pollution control measures.

T8: Prepare a waste minimization plan based on 3-R concepts (Reduce, Reuse, Recycle) for a college campus or household.

T9: Study Environmental Impact Assessment (EIA) procedure for a selected industrial or infrastructure project.

T10: Compare linear economy and circular economy with suitable industrial examples.

T11: Case study on industrial symbiosis and sustainable consumption-production practices.

T12: Prepare a report on sustainable agriculture and sustainable transportation systems.

T13: Study the Sustainable Development Goals (SDGs) and analyse India's progress toward achieving selected SDGs.

T14: Analyse ESG and CSR practices of a reputed company and evaluate their sustainability initiatives.

T15: Prepare a mini-project proposal on green entrepreneurship or sustainable innovation.

T16: Study government policies and initiatives related to sustainability and environmental protection in India.

T17: Industrial visit to suitable plant in consultation with the subject faculty

Learning Resources

Text Books:

1 Allen D. T. and Shonnard D. R., "Sustainability Engineering: Concepts, Design and Case Studies", Publisher: Prentice Hall (2011)
2 Benny Joseph, "Environmental Studies". McGraw Hill Education (2017)
3 Anubha Kaushik, C P Kaushik, "Environmental Studies" New Age International Publisher (2006 or updated version)

4 S. S. Purohit, "Green Technology: An Approach for Sustainable Environment", Agrobios (India)(2010)

Reference Books:

1. The Circular Economy Handbook, Publisher: Palgrave Macmillan
   Focus: Circular economy strategies, business transformation, sustainability frameworks.
2. Towards Zero Waste: Circular Economy Boost, Waste to Resources, Publisher: Springer International Publishing, 2019
3. Circular Economy: Global Perspective, Publisher: Springer, 2020
4. The Circular Economy: A User's Guide, Publisher: Routledge
5. Our Common Future, Publisher: Oxford University Press

e-Books:

1. https://www.scribd.com/document/643696135/Lecture-Notes-Sustainable-Development-pdf
2. https://lecture-notes.tiu.edu.iq/wp-content/uploads/2024/04/1-WEEK-LECTURE_SUSTINABLE-DEVELOPMENT-GAULS-.pdf

MOOC/NPTEL/YouTube Links:

1. nptel.ac.in/courses/107103081 IIT Guwahati NPTEL Video
2. Lec 3: Sustainability and Sustainable Development - Part C Sustainability and Sustainable development IIT Guwahati
3. https://www.youtube.com/watch?v=DVCNPhgC5wE What is Sustainable Development and its importance

Savitribai Phule Pune University Third Year of Chemical Engineering (2024 Pattern) Course Code: ELC-342-CEE Course Name: Technical Seminar		
Teaching Scheme	**Credit**	**Examination Scheme**
Practical: 02 Hours/Week	**01**	**Oral: 25 Marks**

Prerequisite Courses, if any: Basic knowledge of communication

Course Objectives:

After completing this course, students will be able to:

1. Understand the fundamentals of verbal, non-verbal, and written communication required for effective professional interactions in chemical engineering and allied industries.
2. Develop technical writing, presentation, and interpersonal communication skills for preparing engineering reports, delivering technical presentations, and working effectively in multidisciplinary teams.
3. Familiarize themselves with modern communication tools, digital platforms, and emerging technologies used for professional and technical communication in industrial and research environments.
4. Enhance critical thinking, analytical reasoning, and problem-solving abilities through effective communication, collaboration, and professional decision-making.

Course Outcomes:

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

CO1: Understand the fundamental principles of verbal and non-verbal communication, active listening, and professional etiquette required in chemical engineering practice.

CO2: Apply modern communication tools, digital platforms, and emerging technologies to prepare technical documents, presentations, and professional correspondence in engineering environments.

CO3: Demonstrate effective oral, written, and interpersonal communication skills for teamwork, technical discussions, project presentations, and industrial interactions.

CO4: Develop analytical thinking, critical reasoning, and problem-solving skills to address engineering and workplace challenges through effective communication and decision-making.

Course Contents

The seminar may be a review of literature of specific phenomena/new process. Working model to demonstrate the principle, alternatively a small experimentation to investigate chemical engineering. Data/unit process/ unit operation. Based on this study focused report should be submitted. It is expected that the student collect information from reference books, journals and Internet. The report submitted should reveal the student's internalization of the collected information. Mere compilation from the net and other resources is discouraged.

Format of the Seminar report and assessment:

1. The Seminar report should be based on a detailed study of any relevant topic to Chemical Engineering be neatly written or typed on white paper. The typing shall be with normal spacing and on one side of the paper [A-4 size].
2. The report should be submitted with front and back cover of card paper neatly cut and bound or spirally together with the text.
3. Front cover: This shall have the following details.
   a. Title of the seminar report.
   b. The name of the candidate with roll number examination seat number at the middle.
   c. Name of the guide below the candidate's details.
   d. The name of the institute and year of submission on separate lines at the bottom.
4. Seminar approval sheet.
5. The format of the text of the seminar reports:

The introduction should be followed by literature survey. The report of analytical or experimental work done, if any, should then follow. The discussion and conclusions shall form the last part of the text. They should be followed by nomenclature and symbols used followed by acknowledgement. The bibliography should be at the end. References should be written in the standard format. The total number of typed pages, excluding cover shall be about 25 to 30 only. All the pages should be numbered. This includes figures and diagrams. Two copies of the seminar report shall be submitted to the college. The candidate shall present the Seminar before the examiners. The total duration of presentation and after-discussion should be about 30 minutes max. [25 min + 5 min].

The assessment for the subject shall be based on

1. Report submitted.
2. Presentation.
3. Discussion

Learning Resources

1. M. Ashraf Rizvi, *Effective Technical Communication*, McGraw Hill Education, Latest Edition.
2. Meenakshi Raman and Sangeeta Sharma, *Technical Communication: Principles and Practice*, Oxford University Press, Latest Edition.
3. H. S. Mukerjee, *A Handbook of Technical Writing and Communication*, Oxford University Press.

Reference Books:

1. Philip Rubens (Ed.), *Science and Technical Writing: A Manual of Style*, Routledge.
2. Michael Alley, *The Craft of Scientific Presentations*, Springer.
3. Robert A. Day and Barbara Gastel, *How to Write and Publish a Scientific Paper*, Cambridge University Press.The Circular Economy: A User's Guide, Publisher: Routledge

MOOC/NPTEL/YouTube Links:.

1. NPTEL – Courses on Technical Communication, Research Methodology, Chemical Engineering, and Presentation Skills.
2. SWAYAM – MOOCs on communication, research methodology, and engineering subjects.
3. Elsevier Researcher Academy – Research writing, publication ethics, and presentation skills.

4. Springer Nature Research Academy – Scientific writing and publishing resources.
5. Coursera and edX – Courses on presentation skills, scientific communication, and professional development.

NEP 2020 Compliant Curriculum

Structure Third Year Engineering (2024 Pattern)

Chemical Engineering

Third Year Engineering

(With effect from Academic Year 2026-27)

SEMESTER - VI

Savitribai Phule Pune University Third Year of Chemical Engineering (2024 Pattern)		
Course Code: PCC-351-CEE		**Course Name: Reaction Engineering-II**
Teaching Scheme	**Credit**	**Examination Scheme**
Theory: 03 Hours/Week	**03**	**CCE: 30 Marks** **End-Semester: 70 Marks**

Course Objectives:

The objective of the course is to,

1. To understand the fundamentals of heterogeneous reaction systems including fluid-particle and fluid-fluid reactions.
2. To analyze reaction kinetics, rate-controlling mechanisms, and their application in reactor design.
3. To develop knowledge of catalysis, adsorption phenomena, and catalyst characterization techniques.
4. To evaluate mass transport phenomena in porous catalysts and their effect on reaction performance.
5. To apply principles of reaction engineering to industrial catalytic and biochemical reaction systems.

Course Outcomes:

After successful completion of the course, learner will be able to:

CO1: Apply principles of heterogeneous reaction engineering to analyse fluid–particle reaction systems, including identification of rate-controlling steps.

CO2: Develop and interpret rate equations and kinetic regimes for fluid-fluid reactions, and apply them to reactor design and performance analysis.

CO3: Analyse adsorption and catalytic processes, including catalyst characterization, selection, and deactivation mechanisms.

CO4: Evaluate mass transfer and diffusion effects in porous catalysts, including effectiveness factor, selectivity, and design of heterogeneous catalytic reactors.

CO5: Aanalyse industrial reaction systems, including biochemical reaction systems using appropriate kinetic models.

Course Contents

Unit I	Fluid-Particle Reactions	(08 Hours)

Introduction of heterogeneous reaction. Fluid-Particle reactions: Selection of model unreacted core model, progressive conversion model, Rate of reaction for shrinking spherical particles. Determination of rate controlling step, application to design – packed bed reactor and to fluidized bed with entrainment.

Unit II	Fluid – Fluid Reaction	(07 Hours)

Rate equation for reaction, kinetic regimes (case A to H), film conversion parameter, slurry reaction kinetics, aerobic fermentation, application to design (fast and slow reactions), mixer settler, Semi batch contacting pattern, reactive distillation and extractive reactions

Unit III	Catalysis and Adsorption	(07 Hours)

Surface chemistry and adsorption, adsorption isotherms and rates of adsorption. Catalysis: Determination of surface area by BET method, void volume and solid density, pore-volume distribution, catalyst selection, preparation of catalyst and its deactivation, poisoning and regeneration, nature and mechanism of catalytic reactions		
Unit IV	**Porous Catalyst and Catalytic Reactors**	**(07 Hours)**
Porous Catalyst: Gaseous diffusion in single cylindrical pore, diffusion in porous catalyst, surface diffusion, mass transfer with reaction: effectiveness factor, experimental and calculated effectiveness factor, selectivity's for porous catalysts. Heterogeneous Catalytic Reactors: Fixed bed reactor, fluidized bed reactor, slurry reactor		
Unit V	**Solid- catalyzed Reaction and Biochemical Reaction Systems**	**(07 Hours)**
Rate equation (Film resistance, surface phenomenon, pore diffusion) experimental methods for finding rates, determining controlling resistances and rate equation, product distribution in multiple reactions. Biochemical Reaction Systems: Michaelis–Menten (M-M) kinetics, inhibition by foreign substance.		

Learning Resources

Reference Books:

1. Chemical Reaction Engineering: Octave Levenspiel (2^{nd} & 3^{rd} Edition)
2. Chemical Engineering Kinetics: J. M. Smith (3rd Edition)
3. Elements of Chemical Reaction Engineering: H. Scott Fogler (4^{th} Edition)
4. Heterogeneous Reactions: Analysis Examples and reactor Design. Vol.1 & 2- Doraiswamy L. K. and Sharma M. M.

e-Books:

1. Elements of Chemical Reaction Engineering (5^{th} Edition) – H. Scott Fogler : https://ptgmedia.pearsoncmg.com/images/9780133887518/samplepages/9780133887518.pdf
2. Chemical Reaction Engineering (3^{rd} Edition) – Octave Levenspiel : https://the-seventh-dimension.com/images/textlev/LEVENSPIEL%20Chemical%20reaction%20engineering-ch1-ch2.pdf
3. Chemical Engineering Kinetics by J.M. Smith: https://pdfcoffee.com/qdownload/chemical-engineering-kinetics-by-j-m-smith-2-pdf-free.html

MOOC/NPTEL/YouTube Links:

1. Fluid-solid non-catalytic reaction-I: https://www.youtube.com/watch?v=tsX3dZlKOpU
2. Adsorption: https://www.youtube.com/watch?v=dcYe3wPulqQ
3. Fluidized bed design reactor: https://www.youtube.com/watch?v=J33Phm6fJdk
4. Packed bed reactor design: https://www.youtube.com/watch?v=MrI3-9KncgM
5. Enzyme as biocatalyst: https://www.youtube.com/watch?v=ts2FDjj-nkg

Savitribai Phule Pune University Third Year of Chemical Engineering (2024 Pattern)		
Course Code: PCC-352-CEE		**Course Name: Transport Phenomena**
Teaching Scheme	**Credit**	**Examination Scheme**

Theory: 02 Hours/Week	02	CCE: 30 Marks End-Semester: 70 Marks

Prerequisite Courses, if any: Fluid Mechanics, Heat Transfer, Engineering Mathematics.

Course Objectives:

The objective of the course is to develop understanding of momentum, heat, and mass transfer mechanisms and enable application of transport laws to analyze chemical engineering systems.

Course Outcomes:

After successful completion of the course, learner will be able to:

CO1: Apply fundamental laws of momentum transport to analyze fluid flow problems.

CO2: Apply heat transfer principles to evaluate temperature distributions.

CO3: Analyze mass transfer processes using diffusion laws.

CO4: Develop and apply equations of change and macroscopic balances.

CO5: Relate momentum, heat, and mass transfer using analogies and correlations.

Course Contents

Unit I	Fundamentals of Transport and Momentum Transfer	(06 Hours)

Introduction to transport phenomena and analogy between processes, Newton's law of viscosity, Newtonian and Non-Newtonian fluids, Mechanism of momentum transport, Shell momentum balances and velocity distribution in laminar flow through a) circular tube b) falling film c) flow between parallel plates.

Unit II	Energy Transport	(06 Hours)

Fourier's law of heat conduction, Mechanism of energy transport, Thermal conductivity and its dependence, Shell energy balances & Temperature distribution: Plane wall, Cylindrical systems for a) Heat conduction with electrical heat source b) Heat conduction with a viscous heat source c) Heat conduction with a chemical heat source, Introduction to convection and cooling fins.

Unit III	Mass Transport	(06 Hours)

Fick's law of diffusion, Molecular diffusion in gases and liquids, Definitions: concentration, flux, velocity, Shell mass balances and concentration distribution for diffusion through a) stagnant gas film, b) Equimolar counter diffusion c) Diffusion with chemical reaction (homogeneous & heterogeneous)

Unit IV	Equations of Change & Macroscopic Balances	(06 Hours)

Equation of continuity, Equation of motion (Navier-Stokes Equation-Concept), Mechanical energy balance, Dimensional analysis in transport phenomena; Macroscopic balances: Mass balance, Momentum balance, Energy balance; Applications: flow systems, sudden expansion, ejectors.

Unit V	Interphase Transport & Analogies	(06 Hours)
Interphase transport concepts, Friction factors and correlations, Mass transfer coefficients (single and two-phase), Dimensionless numbers: Reynolds, Prandtl, Schmidt, etc.; Analogies: Reynolds analogy, Prandtl analogy, Chilton-Colburn analogy; Introduction to simultaneous heat, mass, and momentum transfer.		

Learning Resources

Text Books:

1. Bird R.B., Stewart W.E., Lightfoot E.N., *Transport Phenomena*, Wiley
2. Geankoplis C.J., *Transport Processes and Separation Process Principles*, PHI

Reference Books:

1. Welty J.R., Wicks C.E., Wilson R.E., *Fundamentals of Momentum, Heat and Mass Transfer*
2. Deen W.M., *Analysis of Transport Phenomena*
3. Gandhi K.S., *Heat and Mass Transfer: A Transport Phenomena Approach*

e-Books:

- https://thestemtutor.org/wp-content/uploads/2024/10/R.-Byron-Bird-Warren-E.-Stewart-Edwin-N.-Lightfoot-Daniel-J.-Klingenberg-Introductory-Transport-Phenomena-Wiley-2014.pdf
- https://web.iitd.ac.in/~hirani/MEL311.pdf
- https://elmoukrie.com/wp-content/uploads/2022/04/richard-g.-griskey-transport-phenomena-and-unit-operations_-a-combined-approach-wiley-interscience-2002.pdf

MOOC/NPTEL/YouTube Links:

1. https://nptel.ac.in/courses/103105128
2. https://onlinecourses.nptel.ac.in/e-learning/preview/noc20_ch06

Savitribai Phule Pune University Third Year of Chemical Engineering (2024 Pattern) Course Code: PCC-353-CEE Course Name: Reaction Engineering Lab		
Teaching Scheme	**Credit**	**Examination Scheme**
Practical: 04 Hours/Week	**02**	**Term Work: 25 Marks** **Practical: 25 Marks**

Prerequisite Courses, if any: Students should have prior knowledge of Chemical Reaction Engineering, material and energy balances, and Chemical Thermodynamics, along with basic laboratory skills, safety practices, and data analysis using computational tools

Course Objectives:

The objective of the course is to

1. **To understand reaction kinetics experimentally**: Determine rate constants, reaction order, and activation energy using laboratory data.
2. **To analyze the performance of different reactors**: Study and compare batch, Continuous Stirred Tank Reactor (CSTR), and Plug Flow Reactor (PFR).
3. **To develop skills in data analysis and modeling** :Apply kinetic models, interpret experimental results, and validate theoretical concepts.

Course Outcomes:

After successful completion of the course, learner will be able to:

CO1: Determine reaction rate constants, order of reaction, and activation energy from experimental data.

CO2: Analyze experimental data to validate different kinetic models for homogeneous reactions.

CO3: Evaluate the performance characteristics of different reactors such as batch, CSTR, and PFR.

CO4: Interpret reactor behavior using conversion, residence time, and rate expressions.

CO5: Develop skills in experimental design, data analysis, and report preparation for reaction engineering systems.

List of Laboratory Experiments (Any 8 experiments from the given list)

Experiment 1: Second Order Reaction

Experiment 2: Pseudo First Order Reaction

Experiment 3: Second Order Reaction By Conductivity Meter

Experiment 4: Pseudo First Order Reaction By Conductivity Meter

Experiment 5: Batch Reactor: Second Order Reaction

Experiment 6: Batch Reactor: Pseudo First Order Reaction

Experiment 7: Study Of Second Order Reaction For Unequal Concentration Of Reactants

Experiment 8: Arrhenius Law

Experiment 9: Continuous Stirred Tank Reactor

Experiment 10: Plug Flow Reactor

Guidelines for Instructor's Manual

- The instructor's manual is to be developed as a hands-on resource and reference.
- Copy of Curriculum, Conduction & Assessment guide lines, List of Experiments to be attached.

Guidelines for Student's Lab Journal

The students Lab Journal should contain following related to every experiment –

1. Title of the experiment
2. Objective
3. Apparatus with their detailed specifications.
4. Brief theory related to the experiment.
5. Connection diagram /circuit diagram.
6. Observation table
7. Sample calculations for one/two reading.
8. Result tables
9. Graph and Conclusions.

Guidelines for Laboratory Conduction

- Completion of any eight experiments from the prescribed syllabus is mandatory.
- Use of open source software and recent version is to been courage.

Guidelines for Lab/TW Assessment

- Continuous assessment of laboratory work is to be done based on overall performance.
- Each lab assignment/experiment assessment will assign grade/marks based on parameters with appropriate weightage.
- Suggested parameters for overall assessment as well as each laboratory assignment include:
  - ✓ Timely completion.
  - ✓ Performance.
  - ✓ Punctuality and neatness.

Learning Resources

Text Books:

1. Elements of Chemical Reaction Engineering: H. Scott, Fogler.

2. Chemical Reaction Engineering: Levenspile O.
3. Chemical Engineering Kinetics: Smith J.
4. Chemical Reaction Engineering – Nishith Verma

Reference Books:

1. Chemical Reaction Engineering: Beyond the Fundamentals – L.K. Doraiswamy & Deniz Uner
2. Coulson and Richardson's Chemical Engineering Volume 3A

e-Books:

1. https://web.iitd.ac.in/~hirani/MEL311.pdf

MOOC/NPTEL/YouTube Links:

1. https://archive.nptel.ac.in/courses
2. https://onlinecourses.nptel.ac.in/noc21_ch33/preview?utm_source=chatgpt.com

Savitribai Phule Pune University Third Year of Chemical Engineering (2024 Pattern) Course Code: PCC-354-CEE Course Name: Chemical Technology & Equipment Design Lab		
Teaching Scheme	**Credit**	**Examination Scheme**
Practical: 02 Hours/Week	**01**	**Term Work: 25 Marks** **Oral: 25 Marks**

Prerequisite Courses, if any: The students should know the basic engineering fundamentals such as material sciences, basic mathematics, momentum and heat transfer, stress- strain analysis and Reaction engineering fundamentals

Course Objectives:

The objective of the course is

To impart fundamentals of process equipment design

To develop understanding of process selection and technology

To introduce process flow diagrams and equipment layout

To provide knowledge of industrial chemical processes

To emphasize safety, environmental, and economic considerations

Course Outcomes:

After successful completion of the course, learner will be able to:

CO1: Apply fundamental design principles including corrosion prevention, stress analysis, and failure theories to the design of pressure vessels and high-pressure equipment.

CO2: Analyze and design reaction vessels and heat exchangers by selecting appropriate configurations, heating systems, and evaluating performance criteria.

CO3: Explain unit operations and processes involved in major inorganic industries such as chlor-alkali, cement, aluminum, and iron & steel production.

CO4: Describe the manufacturing processes, raw materials, and industrial applications of sulfur, nitrogen, sugar, starch, and phosphorus-based products.

CO5: Interpret production routes and process mechanisms for key petrochemicals derived from C-1, C-2, and C-3 compounds.

List of Laboratory Experiments (Any 4 experiments from Sr. No. 1-6 and any 4 experiments from 7-11 from the given list)
Experiment 1: Design and drawing of Pressure vessel
Experiment 2: Design and drawing of High-pressure vessel
Experiment 3: Design and drawing of Shell & Tube Heat Exchanger
Experiment 4: Design and drawing of Double pipe Heat Exchanger

Experiment 5: Design and drawing of Agitated Vessel
Experiment 6: Design and drawing of Reaction Vessel with Limpet coil
Experiment 7: Mass Balance without reaction for Porland cement or any other flow diagram with permission of subject faculty.
Experiment 8: Mass Balance with reaction for Ammonia or Urea or Methanol or Formaldehyde or Chloromethanes or any one flow diagram with permission of subject faculty.
Experiment 9: Energy Balance with reaction for Ammonia or Urea or Methanol or Formaldehyde or Chloromethanes or any one flow diagram with permission of subject faculty.
Experiment 10: Development of flow sheet by stating the problem statement initially. The problem statement should be defined by subject faculty.
Experiment 11: Process flow sheets drawing of **any two** processes using CAD.

Guidelines for Instructor's Manual

- The instructor's manual is to be developed as a hands-on resource and reference.
- Copy of Curriculum, Conduction & Assessment guide lines, List of Experiments to be attached.

Guidelines for Student's Lab Journal

The students Lab Journal should contain following related to every experiment –

1. Title of the experiment
2. Objective
3. Apparatus with their detailed specifications.
4. Brief theory related to the experiment.
5. Connection diagram /circuit diagram.
6. Observation table
7. Sample calculations for one/two reading.
8. Result tables
9. Graph and Conclusions.

Guidelines for Laboratory Conduction

- Completion of any eight experiments from the prescribed syllabus is mandatory.
- Use of open-source software and recent version is to been courage.

Guidelines for Lab/TW Assessment

- Continuous assessment of laboratory work is to be done based on overall performance.
- Each lab assignment/experiment assessment will assign grade/marks based on parameters with appropriate weightage.
- Suggested parameters for overall assessment as well as each laboratory assignment include:

✓ Timely completion.

✓ Performance.

✓ Punctuality and neatness.

Learning Resources

Text Books:

1. V. V. Mahajani, S. B. Umarji, 2014, Joshi's Process Equipment Design, Trinity Press.
2. Sittig M. and Gopala Rao M., Dryden's Outlines of Chemical Technology for the 21st Century, 3rd Edition, WEP East West Press, 2010

Reference Books:

1. Austin G.T., Shreve's Chemical Process Industries - International Student Edition, 5th Edition, McGraw Hill Inc., 1998.
2. J. M. Coulson, J. F. Richardson, R. K. Sinott, 2005, Chemical Engineering Design Vol. 6, Pergamon Press.
3. Unit Processes in Organic Synthesis, Groggins P., McGraw Hill.

e-Books:

1. https://www.scribd.com/document/382802837/Joshi-s-Process-Equipment-Design
2. Dryden&#x27s Outlines of Chemical Technology - PDFCOFFEE.COM

MOOC/NPTEL/YouTube Links:

1. https://www.bing.com/videos/riverview/relatedvideo?q=coursera+on+Chemical+equipment+design&&mid=A910EE45006FF2F58860A910EE45006FF2F58860&churl=https%3a%2f%2fwww.youtube.com%2fchannel%2fUCY-ANi3wxkUSGhAel7T0TGw&FORM=VRDGAR
2. NPTEL Link: https://onlinecourses.nptel.ac.in/noc25_ch15/preview
3. https://www.bing.com/videos/riverview/relatedvideo?q=coursera+on+Chemical+Process+Technology&&mid=C3FC88B40776A17FCD09C3FC88B40776A17FCD09&churl=https%3a%2f%2fwww.youtube.com%2fchannel%2fUC640y4UvDAlya_WOj5U4pfA&mmscn=mtsc&aps=23&FORM=VMSOVR

Savitribai Phule Pune University Third Year of Chemical Engineering (2024 Pattern) Course Code: PEC-361A-CEE Course Name: Chemical Engineering Thermodynamics (Elective)		
Teaching Scheme	**Credit**	**Examination Scheme**
Theory: 03 Hours/Week	**03**	**CCE: 30 Marks** **End-Semester: 70 Marks**

Prerequisite Courses, if any: Knowledge about the thermodynamic properties of substances, the phases and phase equilibrium, Fundamental concepts of reaction kinetics

Course Objectives:

To familiarize students with solution thermodynamics, thermodynamic properties and the concept of equilibrium and the conditions required for achieving equilibrium.

Course Outcomes:

After successful completion of the course, learner will be able to:

CO1: Understand fundamental property relations for homogeneous solutions and study the significance of chemical potential and fugacity for chemical and phase equilibrium.

CO2: Apply knowledge of mathematics and science for calculations of fundamental thermodynamic properties of fluids and understand excess properties, residual properties and property changes of mixing.

CO3: Calculate the temperature, pressure and compositions for vapour liquid equilibrium and analyze and interpret the vapour liquid equilibrium data.

CO4: Understand the concept of phase equilibrium and the conditions to be satisfied for equilibrium and stability for liquid-liquid and solid liquid equilibrium.

CO5: Learn the concept of equilibrium conversion and equilibrium constant for a chemical reaction and calculate the equilibrium compositions for single and multiple reactions.

Course Contents

Unit I	**Solution Thermodynamics**	**(07 Hours)**

State and path functions, intensive and extensive properties, Fundamental property relations for closed systems, Maxwell relationships, residual properties, chemical potential, criteria for phase equilibrium, partial properties, ideal gas mixtures, fugacity and fugacity coefficients for pure species, ideal solutions

Unit II	**Solution Thermodynamic Applications**	**(07 Hours)**

Excess properties, VLE data, fugacity, activity coefficients, excess Gibb’s energy, Margules equation, van Laar equation, property changes of mixing

Unit III	**Vapor-liquid Equilibrium**	**(07 Hours)**

The nature of equilibrium, criteria of equilibrium, effect of T and P on VLE, azeotropes, the phase rule, Duhem's theorem, Raoult's law, VLE by modified Raoult's law, dew point and bubble point calculations, VLE from K-value correlations, Flash calculations, Henry's law.

Unit IV	Phase Equilibria	(07 Hours)

Concept of Equilibrium and stability, liquid-liquid equilibrium, solid-liquid equilibrium, thermodynamic consistency.

Unit V	Chemical Reaction Equilibria	(08 Hours)

The reaction coordinates, Application of the criteria for equilibrium to chemical reactions, the standard Gibbs free energy change and the equilibrium constant, effect of temperature on equilibrium constant, evaluation of the equilibrium constant, Relation of equilibrium constant to composition, calculation of equilibrium conversion for single reactions, The phase rule and Duhem's theorem for reacting systems, multireaction equilibria

Learning Resources

Text Books:

1. Introduction to Chemical Engineering Thermodynamics, J. M. Smith, Hendrick C. Van Ness, M. M. Abbott, Mark Swihart, B I Bhatt, 8th Edition, McGraw Hill Publication
2. A Textbook of Chemical Engineering Thermodynamics, K. V. Narayanan, 2nd Edition PHI Learning Private Ltd.

Reference Books:

1. Chemical Engineering Thermodynamics, Dodge Barnett F., McGraw-Hill Book Company, Inc., New York
2. Chemical Engineering Thermodynamics, T. E. Daubert, McGraw-Hill Book Company, Inc., New York
3. Thermodynamics for Chemical Engineers, Weber, H.C. and Meissner, H.P, Wiley, New York.
4. Chemical and Process Thermodynamics, B. G. Kyle, Prentice- Hall International, Inc.

e-Books:

1. https://www.wiley.com/enie/Chemical%2C+Biochemical%2C+and+Engineering+Thermodynamics%2C+5th+Edition-p-9781119321286

MOOC/NPTEL/YouTube Links:

1. https://nptel.ac.in/courses/103105127
2. https://onlinecourses.nptel.ac.in/noc25_ch61/preview

Savitribai Phule Pune University Third Year of Chemical Engineering (2024 Pattern) Course Code: PEC-361B-CEE Course Name: Energy Conservation in Process Industries (Elective)		
Teaching Scheme	**Credit**	**Examination Scheme**
Theory: 03 Hours/Week	**03**	**CCE: 30 Marks** **End-Semester: 70 Marks**

Prerequisite Courses, if any: Heat transfer, Chemical engineering thermodynamics

Course Objectives:

After Completion of the course student able to apply energy conservation measures in industrial equipment and process operations for efficient and optimum utilization of energy.

Course Outcomes:

After successful completion of the course, learner will be able to:

CO1: Explain various energy sources, energy utilization patterns, environmental impacts, and the significance of energy conservation laws and renewable energy systems.

CO2: Perform basic energy audits, interpret energy performance indicators, and apply energy management techniques for efficient energy utilization.

CO3: Analyse industrial energy supply-demand systems and evaluate energy conservation measures using cost-benefit approaches.

CO4: Organize energy conservation programs by applying management principles, resource allocation, monitoring, and reporting techniques

CO5: Identify and recommend suitable energy-saving practices for industrial utilities and process equipment such as boilers, HVAC systems, compressors, motors, heat exchangers, and lighting systems.

Course Contents

Unit I	Energy Scenario	(07 Hours)

Classification of energy sources, commercial and non-commercial energy, energy resources, commercial energy production, final energy consumption, energy needs of growing economy, long term energy scenario. energy and environment, air pollution, climate change, energy security, energy conservation and its importance, energy strategy for the future, energy conservation act-2001 and its features. Applications of renewable energy sources.

Unit II	Energy Management and Audit	(07 Hours)

Definition, energy audit – need, types of energy audit, energy management (audit) approach understanding energy costs, bench marking, energy performance, matching energy use requirement maximizing system efficiencies, optimizing the input requirements, fuel and energy substitution, energy audit instruments, role, responsibilities and duties of energy manager.

Unit III	Energy Available for Industrial Use	(07 Hours)

Introduction, methodology for forecasting industrial energy supply and demand. New energy technologies and conservation, motivation of implementing conservation measures, evaluating costs and benefits of conservation measures

Unit IV	Management and Organization of Energy Conservation Programs	(07 Hours)

Human aspect of energy conservation, involvement tree, elements of energy management program, promoting energy conservation, program planning, setting goals, setting priorities, allocation of resources, scheduling, measuring, monitoring and reporting, organization of energy conservation programs, plant level organization, division level organization, corporate level organization.

Unit V	Guidelines for Improving Process Operations for Energy Conservation	(08 Hours)

Energy conservation checklist, potential energy conservation in boilers, chilled water plants and central air –conditioning system, compressors and fans, heat pumps and cooling systems, water heaters and coolers, lighting systems, motors and transformers, mixing vessels, heat exchangers, evaporators, distillations, housekeeping.

Learning Resources

Text Books:

1. Industrial Energy Management and Utilization, Larry C. Witte, Philip S. Schmidt, Davis R. Brown. 1988
2. Energy Engineering and Management- Amlan Chakrabarti, PHI Learning-2011

Reference Books:

1. Handbook of Industrial Energy Conservation, S. David HU.
2. Guide book for National Certification Examination for Energy Managers and Energy Auditors- Book 1,2,3 and 4. Bureau of Energy Efficiency (BEE)
3. Energy Conservation in the Process Industries- W. F. Kenny, Academic Press Inc., 1984
4. Energy Conservation in the Chemical and Process Industries, Colin D. Grant, the Institution of Chemical Engineers. 1979
5. Solar Engineering of Thermal Processes, John A. Duffie and William A. Beckman, 3rd Edition-2006

NPTEL link

1. https://www.google.com/url?q=https://onlinecourses.nptel.ac.in/noc26_ge38/preview&sa=D&source=editors&ust=1777449592248527&usg=AOvVaw2_MU9ht2fmDZ78usclnF6B

Savitribai Phule Pune University Third Year of Chemical Engineering (2024 Pattern) Course Code: PCC-361C-CEE — Course Name: AI Applications in Chemical Engineering (Elective)		
Teaching Scheme	**Credit**	**Examination Scheme**
Theory: 03 Hours/Week	**03**	**CCE: 30 Marks** **End-Semester: 70 Marks**

Prerequisite Courses: Basic programming (Python preferred), Chemical Engineering Principles, Idea of Process Control, Mathematics for Engineers.

Course Objectives:

1. To understand the role of AI in process industries.
2. To apply ML techniques to model, optimize, and control chemical processes.
3. To develop data-driven solutions for process design, fault diagnosis, and product engineering.

Course Outcomes:

After successful completion of the course, learner will be able to:

CO1: Identify opportunities for AI/ML in chemical engineering problems.

CO2: Select and implement suitable ML algorithms for regression, classification, and clustering tasks.

CO3: Develop basic AI models using real process data.

CO4: Critically evaluate AI solutions in terms of performance, interpretability, and scalability.

CO5: Utilize AI and ML strategy for Chemical Engineering processes for betterment.

Course Contents

Unit I	Basics of AI in Chemical Engineering	(07 Hours)

Overview of AI and ML in process industries; Data types in chemical engineering: process, experimental, and simulation data; Systems engineering perspective; Historical evolution and current trends; SWOT analysis of AI in chemical engineering.

Unit II	Metaheuristics and Optimization	(07 Hours)

Knowledge-based systems and expert systems, Need of Optimization, Qualitative Idea of novel AI based Optimizers, Genetic Algorithms (GA), Simulated Annealing (SA), Particle Swarm Optimization (PSO).

Unit III	Supervised Learning	(07 Hours)

Regression and classification problems, Linear and logistic regression, Basic idea of: Artificial Neural Networks (ANN), Support Vector Machines (SVM/SVR), Decision Trees and Random Forests and its uses.

Unit IV	Unsupervised Learning and Advancement	(07 Hours)

Clustering: k-means, hierarchical clustering, Dimensionality reduction: Principal Component Analysis (PCA), Bayesian networks and Naive Bayes classifiers, Maximum likelihood estimation, Ethical and practical considerations in AI deployment.

Unit V	Applications in Chemical Engineering	(08 Hours)

Case studies on AI-based optimization: property prediction, yield optimization, fault detection.

AI applied to Chemical Engineering: property prediction, yield optimization, fault detection.

Applications to real life examples: process monitoring, anomaly detection, data visualization.

Learning Resources

Text Books:

1. Artificial Intelligence: A Modern Approach – Stuart Russell and Peter Norvig, 3rd Edition, Prentice Hall, 2010.
2. Applied Machine Learning – M. Gopal, McGraw Hill (India), 2018.
3. AI in Chemical Engineering: Unlocking the Power Within Data – Romagnoli, Briceno-Mena, Manee, Routledge, 2024.
4. Artificial Intelligence in Chemical Engineering – L. T. Fan, Elsevier, 2012

Reference Books:

1. Applications of Artificial Intelligence in Process Systems Engineering – Eds. J. Ren, W. Shen, Y. Man, L. Dong, Elsevier, 2021.
2. Elements of Artificial Neural Networks with Selected Applications in Chemical Engineering, and Chemical & Biological sciences, SS Tambe, PB Deshpande, BD Kulkarni, S Ramani, Simulation & Advanced Controls, Incorporated (1996).
3. Machine Learning – Tom M. Mitchell, McGraw Hill Education, 2017.
4. Applications of Metaheuristics in Process Engineering – Eds. J. Valadi, P. Siarry, Springer, 2014.
5. Pattern Recognition and Machine Learning – Christopher M. Bishop, Springer, 2006.
6. Data Science: Accelerating Innovation and Discovery in Chemical Engineering – AIChE Journal, 2016.

e-Books and e-References:

a. https://www.sciencedirect.com/science/article/abs/pii/S1749772823000465
b. https://aiche.onlinelibrary.wiley.com/doi/10.1002/aic.70358
c. https://www.sciencedirect.com/book/edited-volume/9780443340765/artificial-

intelligence-in-chemical-engineering

d. https://egon.cheme.cmu.edu/ewo/docs/Venkat_CMU_EWOTalk_Mar_2020.pdf

e. https://che.iiserb.ac.in/chemical

f. https://academic.oup.com/ce/article/9/5/55/8263023

g. https://www.chemcopilot.com/blog/artificial-intelligence-in-chemical-engineering-a-complete-guide

MOOC/NPTEL/YouTube Links:

1. https://nptel.ac.in/courses/113104517
2. https://nptel.ac.in/courses/106106198
3. https://onlinecourses.nptel.ac.in/e-learning/preview/noc25_ge77
4. https://www.youtube.com/watch?reload=9&v=H3xX4fz35Zc
5. http://www.digimat.in/nptel/courses/video/113104517/L75.html

Savitribai Phule Pune University Third Year of Chemical Engineering (2024 Pattern) Course Code: PEC-362A-CEE Course Name: Separation Technologies (Elective)		
Teaching Scheme	**Credit**	**Examination Scheme**
Theory: 03 Hours/Week	**03**	**CCE: 30 Marks** **End-Semester: 70 Marks**

Prerequisite Courses, if any:

Course Objectives:

The objective of the course is :

1. To understand the principles, mechanisms, and design aspects of various separation processes used in chemical, environmental, and process industries.
2. To develop knowledge of leaching, ion exchange, crystallization, and advanced separation technologies for industrial applications.
3. To analyze and evaluate the performance of conventional and novel separation techniques for the recovery, purification, and treatment of materials.

Course Outcomes:

After successful completion of the course, learner will be able to:

CO1: Evaluate the design and operation of advanced distillation processes, including azeotropic and extractive distillation, and select appropriate entrainers for industrial separation problems through case studies.

CO2: Evaluate and select suitable extraction and leaching equipment for industrial applications by considering process requirements, operating conditions, and design parameters.

CO3: Analyse the operation and design of Pressure Swing Adsorption (PSA), Temperature Swing Adsorption (TSA), and ion exchange systems by applying equilibrium concepts and solving design-related problems.

CO4: Apply engineering principles to analyse and solve problems related to crystallization and membrane separation processes such as ultrafiltration, nanofiltration, and reverse osmosis.

CO5: Analyse the performance and design considerations of hybrid separation processes such as membrane–distillation, adsorption–membrane, and extraction–membrane systems for enhanced process efficiency.

Course Contents

Unit I	**Distillation**	**(08 Hours)**

Vapour-liquid equilibria for ideal and non-ideal systems, Methods of distillation, Lewis Sorel method and problems, McCabe Thiele method and problems, Multicomponent distillation- basic principles, Low key high key components, concept of K value and its application in design, Tray to tray calculations, Thiele-Geddes and Maddox methods, case studies, Azeotropic and extractive distillation, choice of entrainer

Unit II	**Extraction**	**(07 Hours)**

Ternary liquid equilibria. Single stage extraction and problems, Multistage crosscurrent Extraction and problems. Continuous contact extraction in packed towers and its HTU and NTU concept. Study of stage and differential type extractors. Equilibrium concept of ideal stage leaching. Constant and variable underflow, operating time. Methods to calculate number of ideal stages. Calculation of single stage and multistage leaching processes. Leaching equipment

Unit III	Adsorption and Ion Exchange Processes	(07 Hours)
Definition and basic principles of adsorption Physical and chemical adsorption. Break through curve and adsorption hysteresis. Single and multistage adsorption calculations. Langmuir and Freundlich adsorption isotherm, Pressure swing adsorption (PSA), and Temperature swing adsorption (TSA)., Basic principles and Equilibria concept of Ion Exchange, Techniques and applications of Ion Exchange Equipment's used and Problems. Water softening, Nuclear waste treatment, pharmaceutical purification		
Unit IV	**Crystallization and Membrane Separation Processes**	**(07 Hours)**
Basic principles and steps involved in crystallization. Solubility curve and methods of super saturation. Mier's super saturation theory, material and energy balances of crystallization, Ultra filtration, Nano filtration, Reverse osmosis. Types of membranes, Fluxes and driving forces in membrane separation processes. Electrodialysis and electrochemical separations. Supercritical fluid extraction. Hybrid separation processes. Emerging trends and sustainable separation technologies.		
Unit V	**Reactive Separation Processes**	**(07 Hours)**
Separation based on reversible chemical complexation, Reactive distillation, Reactive extraction Reactive crystallization, Working principles and process design aspects, Membrane + Distillation hybrid process, Adsorption + Membrane, Extraction + Membrane		

Learning Resources

Text Books:

1. Treybal R.E. "Mass Transfer Operation",
2. King C. J. "Separation Processes", McGraw Hill
3. 3. A.L. Lyderson, "Mass Transfer in Engineering Practices", John Wiley

Reference Books:

1. Richardson J. F. and Coulson J.M. "Chemical Engineering", Vol. I, II
2. McCabe and Smith, 'Unit Operations in Chemical Engineering"
3. Henley E. J. and Seader H.K. "Stage wise Process Design," McGraw Hill
4. Smith B.D., "Design of Equilibrium Stage Process".
5. Foust A.S., "Principles of Unit Operations"

e-Books:

1. https://madar-ju.com/storage/images/files/file_1738183972cY9Rl.pdf
2. https://sist.sathyabama.ac.in/sist_coursematerial/uploads/SCH1314.pdf
3. https://scispace.com/pdf/handbook-of-separation-process-technology-edited-by-r-w-1can62eaqd.pdf

MOOC/NPTEL/YouTube Links:

1. https://www.youtube.com/watch?v=0WAc06ldbLs
2. https://www.youtube.com/watch?v=1BMfz_vmwtg
3. https://www.youtube.com/watch?v=0-H195JR5i0
4. https://www.youtube.com/watch?v=RW6jiE-K6rA
5. https://www.youtube.com/watch?v=_LSKHSQmwwE

Savitribai Phule Pune University Third Year of Chemical Engineering (2024 Pattern) Course Code: PCC-362B-CEE Course Name: Analytical Techniques (Elective)		
Teaching Scheme	**Credit**	**Examination Scheme**
Theory: 03 Hours/Week	**03**	**CCE: 30 Marks** **End-Semester: 70 Marks**

Prerequisite Courses, if any: Engineering Chemistry, Environmental Chemistry

Course Objectives:

The objective of the course is to provide fundamental understanding of principles and components of analytical instrumentation.

Course Outcomes:

After successful completion of the course, learner will be able to:

CO1**:** Explain the fundamental principles, components, and operational characteristics of modern analytical instrumentation systems used in chemical analysis.

CO2**:** Analyze and interpret data obtained from various spectroscopic techniques (e.g., UV–Vis, IR, and atomic spectroscopy) for qualitative and quantitative analysis.

CO3: Evaluate the working principles and applications of chromatographic separation techniques (e.g., GC, HPLC) for complex mixture analysis and industrial processes.

CO4: Apply the principles of electrochemical methods including pH measurement, conductivity analysis, polarography, and ion-selective electrodes for process monitoring and control.

CO5: Interpret results from thermal analysis techniques (e.g., TGA, DSC, DTA) to determine material properties such as stability, composition, and phase transitions.

Course Contents

Unit I	**Introduction to Analytical Instruments**	**(06 Hours)**

Purpose and methods of chemical analysis (qualitative vs. quantitative). Components of analytical instruments: Signal sources, transducers, detectors, and data processors. Calibration techniques and industrial applicability.

Unit II	**Spectroscopic Techniques**	**(06 Hours)**

UV-Vis Spectroscopy: Principles, working mechanism and applications in liquid analysis.
FTIR Spectroscopy: Principles, working mechanism and applications in liquid analysis and structure analysis of compounds.
Atomic Absorption Spectroscopy (AAS): Principles, working mechanism, Metal and elemental analysis.

X-ray Methods: Fluorescence (XRF) and diffraction techniques.		
Unit III	**Chromatography techniques**	**(06 Hours)**
Liquid Chromatography (HPLC/TLC): High-performance liquid chromatography principles and applications; Gas Chromatography (GC): Principles, columns, detectors, and carrier gases for volatile compounds; Hyphenated Techniques: GC-MS, LC-MS for complex mixture analysis.		
Unit IV	**Electrochemical methods**	**(06 Hours)**
Conductometry: Concept of conductivity, its measurement, and conductometric titrations with applications; Potentiometry: Principle of potentiometer, electrodes, pH measurement, and potentiometric titrations; Voltammetry & Polarography: Fundamentals of voltammetry, polarography, dropping mercury electrode, and applications; Coulometry: Faraday's laws, types of coulometry, and analytical applications		
Unit V	**Thermal Methods**	**(06 Hours)**
Applications of thermal methods for analysis; Thermogravimetry (TGA), Differential Thermal Analysis (DTA), and Differential Scanning Calorimetry (DSC).		

Learning Resources

Text Books:

1. Chatwal, G. R., & Anand, S. K. (1979). *Instrumental methods of chemical analysis* (Vol. 2). Mumbai Himalaya publishing house.
2. Skoog, Douglas A., F. James Holler, and Stanley R. Crouch. *Instrumental analysis*. Vol. 47. Belmont, CA, USA: Brooks/Cole, Cengage Learning, 2007.

Reference Books:

1. Analytical Chemistry, Ed. by Kellner, Mermet, Otto, Valcarcel, Widmer, Second Ed. Wiley – VCH
2. Liquid Chromatography Mass Spectrometry: An Introduction by Bob Ardery, Publisher: Wiley India Pvt. Ltd. (2003). A book from series- Analytical techniques in the Science.
3. Principles of Thermal Analysis and Calorimetry, P. J. Haines, Royal Society of Chemistry

e-Books:

1. https://drive.google.com/file/d/1jGqnQlLQRkjW194-ecRHxaqoYKNy53IV/view

MOOC/NPTEL/YouTube Link:

1. https://archive.nptel.ac.in/courses/

Savitribai Phule Pune University Third Year of Chemical Engineering (2024 Pattern) Course Code: PCC-362C-CEE Course Name: Computational Fluid Dynamics (Elective)		
Teaching Scheme	**Credit**	**Examination Scheme**
Theory: 03 Hours/Week	**03**	**CCE: 30 Marks** **End-Semester: 70 Marks**

Prerequisite Courses, if any: Fluid Mechanics, Heat Transfer, Mass transfer, Engineering Mathematics, Numerical Methods

Course Objectives:

To develop an understanding for the major theories, approaches and methodologies used in CFD.

To impart knowledge about the application of CFD analysis to real engineering designs.

The CFD techniques can be applied for solving practical problems in fluid flow, heat and mass transfer.

To equip students with the knowledge of using commercial software package.

Course Outcomes:

After successful completion of the course, learner will be able to:

CO1: Describe the general form and solution strategy for transport phenomena problem

CO2: Understand how general governing equations are converted into specific solutions through examples.

CO3: Review and apply the fundamental vector and matrix operators used in the formulation and analysis of Transport Phenomena problems

CO4: Understand the concept of diffusive transport of conserved quantities: Fick's Law, Fourier's Law, Newton's Law

CO5: Become familiar with the general expression for diffusive flux of a conserved quantity

Course Contents

Unit I	Introduction to Computational Fluid Dynamics	(06 Hours)

Introduction of CFD, Definition and scope of CFD, Applications, comparison between numerical, analytical and experimental approaches, modelling versus experimentation, Advantages and limitations of CFD,

Unit II	Principles of Conservation	(06 Hours)

Fundamental principles of conservation, Reynolds transport theorem, conservation of mass, conservation of linear momentum: Navier-Stokes equation, conservation of energy, general scalar transport equation.

Unit III	Classification of Partial Differential Equations	(06 Hours)
Introduction to Partial Differential Equation, Definition of PDE, Order and degree of PDE, Linear and nonlinear PDEs, Homogeneous and non-homogeneous equations, physical and mathematical classifications of PDEs, systems of partial differential equations, boundary conditions.		
Unit IV	**Finite Difference Method**	**(06 Hours)**
Discretization principles, truncation and round-off error, explicit and implicit approaches, basic of finite difference method, treatment of boundary conditions, assessing accuracy and stability of numerical methods, finite difference applications in heat conduction and convection: steady heat conduction in rectangular geometries, convective heat transfer, stream function formulation.		
Unit V	**Finite Volume Method**	**(06 Hours)**
Discretization methods, the four basic rules, one-dimensional steady and unsteady diffusion problems, two and three dimensional situations, convection and diffusion for one-dimensional steady problems, various discretization schemes, solution of discretized equations, pressure and velocity corrections, pressure velocity coupling		

Learning Resources

Text Books:

1. Transport Phenomena by R. B. Bird, W. E. Stewart, E. E. Lightfoot, 2nd edition, John Wiley & Sons, 2007.
2. Analysis of Transport Phenomena by W. M. Deen, 2nd edition, Oxford University Press, 2013.

Reference Books:

1. Computational Fluid Dynamics: The Basics with Applications Anderson, J. D. Jr. (1995). *Computational fluid dynamics: The basics with applications*. McGraw-Hill Education.
2. An Introduction to Computational Fluid Dynamics: The Finite Volume Method Versteeg, H. K., & Malalasekera, W. (2007). *An introduction to computational fluid dynamics: The finite volume method* (2nd ed.). Pearson Education.
3. Computational Methods for Fluid Dynamics Ferziger, J. H., & Perić, M. (2002). *Computational methods for fluid dynamics* (3rd ed.). Springer.

e-Books:

1. https://elmoukrie.com/wp-content/uploads/2022/05/joel-h.-ferziger-milovan-peric-robert-l.-street-computational-methods-for-fluid-dynamics-springer-international-publishing-2020.pdf
2. https://home.czu.cz/storage/575/52485_computational-fluid-dynamics.pdf

MOOC/NPTEL/YouTube Links:

1. https://www.classcentral.com/course/youtube-computational-fluid-dynamics-for-incompressible-flows-47444?utm_source=chatgpt.com

Savitribai Phule Pune University Third Year of Chemical Engineering (2024 Pattern) Course Code: PEC-363A-CEE Course Name: Separation Technologies Lab (Elective Lab)		
Teaching Scheme	**Credit**	**Examination Scheme**
Practical: 02 Hours/Week	**01**	**Term Work: 25 Marks** **Practical: 25 Marks**

Prerequisite Courses, if any:

Course Objectives:

The objective of the course is -

1. To provide hands-on experience in operating separation equipment and analyzing process performance.
2. To develop skills in evaluating separation efficiency and process parameters.
3. To familiarize students with conventional and advanced separation techniques used in industry.

Course Outcomes:

After successful completion of the course, learner will be able to:

CO1: Perform leaching, ion exchange, crystallization, and membrane separation experiments safely and accurately.
CO2: Evaluate separation efficiency and determine key process parameters experimentally.
CO3: Interpret experimental data and compare the performance of different separation techniques.
CO4: Apply laboratory findings to solve practical industrial and environmental separation problems.

Course Contents

List of Laboratory Experiments (Any 8 experiments from the given list)
Experiment 1: Determination of solid-liquid extraction efficiency in a batch leaching process.
Experiment 2: Study of effect of particle size on leaching rate.
Experiment 3: Study of effect of temperature on leaching efficiency
Experiment 4: Water softening using cation exchange resin.
Experiment 5: Demineralization of water using mixed-bed ion exchange resins.
Experiment 6: Determination of ion exchange capacity of a resin.
Experiment 7: Study of regeneration characteristics of ion exchange resins.
Experiment 8: Determination of solubility curve of a crystalline salt.
Experiment 9: Batch crystallization and crystal yield determination.
Experiment 10: Study of crystal size distribution using sieve analysis.
Experiment 11: Recovery of crystals from solution using cooling crystallization.
Experiment 12: Separation using membrane filtration (UF/NF/RO demonstration).
Experiment 13: Mini-project on selection and design of a suitable separation process for an industrial effluent.
Experiment 14: Differential Distillation
Experiment 15: Sieve plate column

Guidelines for Instructor's Manual

- The instructor's manual is to be developed as a hands-on resource and reference.
- Copy of Curriculum, Conduction & Assessment guide lines, List of Experiments to be attached.

Guidelines for Student's Lab Journal

The students Lab Journal should contain following related to every experiment –

1. Title of the experiment
2. Objective
3. Apparatus with their detailed specifications.
4. Brief theory related to the experiment.
5. Connection diagram /circuit diagram.
6. Observation table
7. Sample calculations for one/two reading.
8. Result tables
9. Graph and Conclusions.

Guidelines for Laboratory Conduction

- Completion of any eight experiments from the prescribed syllabus is mandatory.
- Use of open source software and recent version is to been courage.

Guidelines for Lab/TW Assessment

- Continuous assessment of laboratory work is to be done based on overall performance.
- Each lab assignment/experiment assessment will assign grade/marks based on parameters with appropriate weightage.
- Suggested parameters for overall assessment as well as each laboratory assignment include:
  - ✓ Timely completion.
  - ✓ Performance.
  - ✓ Punctuality and neatness.

Reference Books:

1. McCabe, W. L., Smith, J. C., & Harriott, P. (2017). *Unit Operations of Chemical Engineering* (7th ed.). McGraw-Hill Education.
2. Seader, J. D., Henley, E. J., & Roper, D. K. (2016). *Separation Process Principles* (4th ed.). John Wiley & Sons.
3. Treybal, R. E. (1980). *Mass Transfer Operations* (3rd ed.). McGraw-Hill.
4. Geankoplis, C. J. (2018). *Transport Processes and Separation Process Principles* (5th ed.). Prentice Hall.
5. Green, D. W., & Southard, M. Z. (Eds.). (2019). *Perry's Chemical Engineers' Handbook* (9th ed.). McGraw-Hill Education.
6. Gavhane, K. A. (2017). *Chemical Engineering Laboratory Manual*. Nirali Prakashan.
7. Badger, W. L., & Banchero, J. T. *Introduction to Chemical Engineering*. McGraw-Hill.
8. Ho, W. S. W., & Sirkar, K. K. (Eds.). *Membrane Handbook*. Springer.
9. Nachod, F. C., & Schubert, J. (Eds.). *Ion Exchange Technology*. Academic Press.
10. Mullin, J. W. (2001). *Crystallization* (4th ed.). Butterworth-Heinemann.

Savitribai Phule Pune University Third Year of Chemical Engineering (2024 Pattern) Course Code: PCC-363B-CEE Course Name: Analytical Techniques Lab (Elective Lab)		
Teaching Scheme	**Credit**	**Examination Scheme**
Practical: 02 Hours/Week	**01**	**Term Work: 25 Marks** **Practical: 25 Marks**

Prerequisite Courses, if any: Engineering Chemistry, Environmental Chemistry

Course Objectives:

1. To familiarize students with the operation and components of modern analytical instruments used in chemical analysis.
2. To develop skills in performing spectroscopic techniques and interpreting experimental data for qualitative and quantitative analysis.
3. To provide hands-on experience in chromatographic methods for separation and analysis of chemical mixtures.
4. To train students in the application of electrochemical techniques for measurement and process monitoring.
5. To introduce thermal analysis methods and enable interpretation of material properties based on experimental data

Course Outcomes:

After successful completion of the course, learner will be able to:

CO1: Operate and identify the components of modern analytical instruments used in chemical analysis and understand their basic working principles.

CO2: Perform spectroscopic experiments (UV–Vis, IR, atomic spectroscopy) and interpret data for qualitative and quantitative analysis.

CO3**:** Carry out chromatographic separations (TLC/GC/HPLC) and evaluate results for analysis of mixtures and industrial samples.

CO4: Apply electrochemical techniques such as pH measurement, conductometry, and potentiometry for analysis and process monitoring.

CO5: Analyze and interpret data obtained from thermal analysis techniques (TGA, DSC, DTA) to assess material properties and behavior.

Course Contents

List of Laboratory Experiments (Any 8 experiments from the given list)

Unit I	**Introduction to Analytical Instrumentation**	

1. Calibration of Analytical Balance
   Objective: To calibrate and evaluate accuracy and precision of a balance.
2. Preparation of Standard Solutions & Calibration Curve
   Objective: Prepare standard solutions and plot calibration curve (Beer-Lambert concept).
3. Study of Instrument Components
   Objective: Identify and understand parts of instruments (source, detector, and transducer).

Unit II	**Spectroscopic Techniques**	

1. UV-Visible Spectroscopy *(Demonstration/Hands-on)*
   Determination of concentration of a colored solution using Beer-Lambert Law.
2. FTIR Analysis *(Demonstration/Hands –on))*
   Identification of functional groups in organic compounds using FTIR spectra.
3. Atomic Absorption Spectroscopy (AAS) *(Demonstration/Hands-on)*
   Estimation of metal ions (e.g., Ca, Fe) in water samples.
4. ICP-OES / ICP-MS *(Demonstration)*
   Multi-element analysis of industrial sample.
5. XRF / XRD Demonstration *(Demonstration)*
   Phase identification or elemental composition study.

Unit III	**Chromatography techniques**	

1. Thin Layer Chromatography (TLC) *(Demonstration/Hands-on)*
   Separation and identification of components in a mixture on TLC plate
2. High Performance Liquid Chromatography (HPLC) *(Demo/Visit)*
   Analysis of pharmaceutical/organic compounds.
3. Gas Chromatography (GC) *(Demo)*
   Separation of volatile compounds (e.g., solvents mixture).
4. Chromatographic Parameter Calculation
   Determination of Rf value, resolution, and efficiency.

Unit IV	**Electrochemical methods**	

1. Conductometric Titration *(Demonstration/Hands-on)*
   Strong acid vs strong base titration.
2. Potentiometric Titration *(Demonstration/Hands-on)*
   Determination of equivalence point using pH meter.
3. pH Measurement and Buffer Preparation *(Demonstration/Hands-on)*
   Calibration of pH meter and buffer analysis.
4. Voltammetry / Polarography *(Demo)*
   Study of current vs voltage curve.
5. Coulometric Analysis *(Demo/Problem-based)*
   Determination of analyte using charge passed.
6. Ion-Selective Electrode Experiment
   Measurement of specific ions (e.g., fluoride, chloride).

Unit V	**Thermal Methods**	

1. Thermogravimetric Analysis (TGA) *(Demo)*
   Study of weight loss vs temperature.
2. Differential Scanning Calorimetry (DSC) *(Demo)*
   Determination of melting point and phase transitions.
3. Differential Thermal Analysis (DTA) *(Demo)*
   Thermal behavior comparison of materials.

Guidelines for Instructor's Manual

- The instructor’s manual is to be developed as a hands-on resource and reference.
- Copy of Curriculum, Conduction & Assessment guide lines, List of Experiments to be attached.

Guidelines for Student's Lab Journal

The students Lab Journal should contain following related to every experiment –

1. Title of the experiment
2. Objective
3. Apparatus with their detailed specifications.
4. Brief theory related to the experiment.
5. Connection diagram /circuit diagram.
6. Observation table
7. Sample calculations for one/two reading.
8. Result tables
9. Graph and Conclusions.

Guidelines for Laboratory Conduction

• Completion of any eight experiments from the prescribed syllabus is mandatory.

Guidelines for Lab/TW Assessment

- Continuous assessment of laboratory work is to be done based on overall performance.
- Each lab assignment/experiment assessment will assign grade/marks based on parameters wi appropriate weightage.
- Suggested parameters for overall assessment as well as each laboratory assignment include:
  - ✓ Timely completion.
  - ✓ Performance.
  - ✓ Punctuality and neatness.

Learning Resources

Reference Books:

1. Analytical Chemistry, Ed. by Kellner, Mermet, Otto, Valcarcel, Widmer, Second Ed. Wiley –VC
2. Liquid Chromatography Mass Spectrometry: An Introduction by Bob Ardery, Publisher: Wiley I Pvt. Ltd. (2003). A book from series- Analytical techniques in the Science.
3. Principles of Thermal Analysis and Calorimetry, P. J. Haines, Royal Society of Chemistry

e-References:

1. https://drive.google.com/file/d/1jGqnQlLQRkjW194-ecRHxaqoYKNy53IV/view
2. file:///C:/Users/Admin/Downloads/analytical-chemistry-libretexts-1535.pdf

Savitribai Phule Pune University Third Year of Chemical Engineering (2024 Pattern) Course Code: PCC-363C-CEE Course Name: Computational Fluid Dynamics Lab (Elective Lab)		
Teaching Scheme	**Credit**	**Examination Scheme**
Practical: 02 Hours/Week	**01**	**Term Work: 25 Marks** **Practical: 25 Marks**

Prerequisite Courses, if any: Fluid Mechanics, Heat Transfer, Mass transfer, Engineering Mathematics, Numerical Methods

Course Objectives:

1. To introduce students to CFD software tools and simulation workflow used in chemical engineering applications.
2. To develop skills in geometry creation, mesh generation, and specification of boundary conditions for fluid flow problems.
3. To apply numerical methods for analyzing fluid flow, heat transfer, and mass transfer phenomena.
4. To perform CFD simulations for chemical engineering equipment such as pipes, reactors, heat exchangers, and mixing systems.
5. To interpret and Analyze CFD results using contour plots, velocity vectors, streamlines, and convergence studies.

Course Outcomes:

After successful completion of the course, learner will be able to:

CO1: Demonstrate proficiency in using CFD software tools for engineering simulations.

CO2: Generate computational domains and high-quality meshes for fluid flow and heat transfer problems.

CO3: Apply appropriate boundary conditions and numerical models for CFD analysis.

CO4: Perform simulations of fluid flow, heat transfer, mixing, and mass transfer operations relevant to chemical engineering.

CO5: Analyze and interpret CFD results using contour plots, streamlines, vectors, and convergence criteria.

Course Contents

List of Laboratory Experiments (Any 8 practical from the given list)

Experiment 1: Introduction to CFD software and simulation methodology using ANSYS Fluent, OpenFOAM or any other software.

Experiment 2: Geometry creation, computational domain setup, and mesh generation.

Experiment 3: Mesh quality analysis and grid independence study.

Experiment 4: Simulation of laminar flow through a circular pipe and comparison with analytical solutions.

Experiment 5: Turbulent flow analysis in pipes using standard turbulence models.

Experiment 6: CFD analysis of flow through sudden expansion and contraction.

Experiment 7: Simulation of one-dimensional steady-state heat conduction problem.

Experiment 8: Numerical solution of one-dimensional convection–diffusion equation.

Experiment 9: Simulation of heat transfer in ducts and heat exchangers.

Experiment 10: Mixing analysis in stirred tank reactors and agitated vessels.

Experiment 11: Species transport and diffusion simulation in chemical process systems.

Experiment 12: Packed bed reactor simulation using porous media approach.

Experiment 13: Multiphase flow simulation for gas–liquid or solid–fluid systems.

Experiment 14: CFD analysis of cyclone separator and particle separation efficiency.

Guidelines for Instructor's Manual

- The instructor's manual is to be developed as a hands-on resource and reference.

Copy of Curriculum, Conduction & Assessment guide lines, List of Experiments to be attached

Guidelines for Student's Lab Journal

The students' CFD Lab Journal should contain the following details for each experiment:

1. Title of the experiment.
2. Objective of the simulation study.
3. Software/tools used with detailed specifications (e.g., ANSYS Fluent, OpenFOAM, processor configuration, solver type, etc.).
4. Brief theory and governing equations related to the problem.
5. Geometry/model description and mesh generation details.
6. Boundary conditions and simulation parameters.
7. Observation tables and monitored simulation data.
8. Sample calculations and validation for selected results.
9. Contour plots, vector plots, streamlines, graphs, and discussion of results.
10. Conclusions and engineering interpretations of the simulation study.

Guidelines for Laboratory Conduction

- Completion of any eight experiments from the prescribed syllabus is mandatory.

Learning Resources

Reference Books:

1. Computational Fluid Dynamics: The Basics with Applications Anderson, J. D. Jr. (1995). *Computational fluid dynamics: The basics with applications*. McGraw-Hill Education.

2. An Introduction to Computational Fluid Dynamics: The Finite Volume Method Versteeg, H. K., & Malalasekera, W. (2007). *An introduction to computational fluid dynamics: The finite volume method* (2nd ed.). Pearson Education.
3. Computational Methods for Fluid Dynamics: Ferziger, J. H., & Perić, M. (2002). *Computational methods for fluid dynamics* (3rd ed.). Springer

e-Books:

1. https://elmoukrie.com/wp-content/uploads/2022/05/joel-h.-ferziger-milovan-peric-robert-l.-street-computational-methods-for-fluid-dynamics-springer-international-publishing-2020.pdf
2. https://home.czu.cz/storage/575/52485_computational-fluid-dynamics.pdf

Savitribai Phule Pune University
Third Year of Chemical Engineering (2024 Pattern)

Course Code: MDM-371-CEE **Course Name: Advanced Numerical Techniques**

Teaching Scheme	Credit	Examination Scheme
Theory: 02 Hours/Week	02	CCE: 15 Marks End-Semester: 35 Marks

Prerequisite Courses, if any: Differential & Integral calculus, Ordinary Differential Equations, Collection, classification & representation of data

Course Objectives:

To familiarize the students with concepts and techniques in solutions of Partial differential equations, Applications of Integral transforms Laplace transforms Fourier & Z-Transform and Inferential Statistics. The aim is to equip them with the techniques to understand advanced level mathematics and its applications that would enhance analytical thinking power, useful in their disciplines.

Course Outcomes:

After successful completion of the course, learner will be able to:

CO1: Solve Partial differential equations and its applications to chemical engineering problems.

CO2: Apply finite difference methods to solve partial differential equation occurring in Heat transfer \ and chemical Engineering problems

CO3: Apply Integral transform techniques such as Laplace transform to solve differential equations in chemical engineering applications.

CO4: Apply other Integral transform techniques such as Fourier transform & Z-transforms to solve differential equations in chemical engineering applications.

CO5: Apply the techniques of sampling distributions of sample mean, Sample proportion and central limit theorem useful in statistical inferences and in testing of hypothesis.

Course Contents

Unit I	Applications of Partial Differential Equations (PDE)	(06 Hours)

Introduction, Basic concepts, Modelling of one-dimensional wave equation (Vibration of string), one- and two-dimensional Heat flow equations, Method of Separation of variables, Use of Fourier series, Applications of PDE to problems of Chemical and allied engineering.

Unit II	Numerical Solution of Partial Differential Equations (PDE)	(06 Hours)

Introduction, Classification of second order partial differential Equations, Explicit and Implicit Finite difference approximations, Stability of finite difference method, Numerical solutions of one-dimensional Heat flow equation, Two-dimensional Laplace equation and one-dimensional Wave equation. Iterative method.

Unit III	Applications of Laplace Transform (LT)	(06 Hours)

Definition of LT, Inverse LT, Properties & theorems, Applications of LT for solving LDE, liquid level systems consisting of single tank and two tanks in series (interacting and non-interacting systems), Second order systems (Damped vibrator).

Unit IV	Fourier and Z-Transforms	(06 Hours)

Fourier Transform (FT): Fourier integral theorem. Fourier Sine & Cosine integrals. Fourier transform (FT), Fourier Cosine transform, Fourier Sine transforms and their inverses. Finite FT, Application of FT to problems on one- and two-dimensional heat flow problems.

Z – Transform (ZT): Introduction, Definition, Standard properties, ZT of standard sequences and their inverses. Applications of Z – transform to solve difference equations.

Unit V	**Inferential Statistics & AI Applications**	**(06 Hours)**

Sampling Theory: Population and sample, Types of sampling: Random sampling, Stratified sampling, Systematic sampling, Sampling distributions, Sample mean, Sample proportion Standard error, Central Limit Theorem (statement only).

Hypothesis Testing: Null and alternative hypotheses, Type-I and Type-II errors, Level of significance, One-tailed and two-tailed tests, z-test, t-test, p-value concept. Analysis of Variance (ANOVA): One-way, Two-way (with and without interactions), F-test interpretation, Comparison of multiple datasets.

Statistical Learning Concepts for AI: Introduction to statistical learning, Training and testing datasets, Error metrics: MAE, MSE, RMSE.

Learning Resources

Text Books:

1. Higher Engineering Mathematics by B. S. Grewal (Khanna Publication, Delhi).
2. Advanced Engineering Mathematics, 10e, by Erwin Kreyszig (Wiley India).

Reference Books:

1. Higher Engineering Mathematics by B.V. Ramana (Tata McGraw-Hill).
2. Partial Differential Equations for Scientists and Engineers by S. J. Farlow (Dover Publications, 1993)
3. Numerical Methods for Engineers, Steven C Chapra & Raymond P Canale, TMH, Fifth Edition
4. Numerical methods for scientific and engineering computation, Jain, Iyangar Jain, New Age International Publishers
5. Applied Numerical Analysis, Curtis F. Gerald and Patrick O. Wheatley, Pearson Education, Inc
6. Introduction to Probability and Statistics for Engineers and Scientists, 5e, by Sheldon M. Ross (Elsevier Academic Press)

Savitribai Phule Pune University Third Year of Chemical Engineering (2024 Pattern) Course Code: VSE-373-CEE Course Name: Solar Technology and Maintenance		
Teaching Scheme	**Credit**	**Examination Scheme**
Practical: 02 Hours/Week	**01**	**Term Work: 25 Marks** **Oral: 25 Marks**

Prerequisite Courses, if any: Basic knowledge of Physics, Electrical Engineering, Basic Electronics, Semiconductor Devices, Energy Conversion, Electrical Measurements, and Renewable Energy concepts.

Course Objectives:

- To apply safe installation, wiring, testing, and commissioning practices for solar PV systems
- To analyze the impact of environmental and operational conditions on solar PV system performance.
- To evaluate maintenance and troubleshooting procedures for solar photovoltaic systems and associated equipment.
- To develop practical solutions and technical documentation for improving solar energy system efficiency and reliability.

Course Outcomes:

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

- Apply safe installation, wiring, commissioning, and performance measurement techniques for solar PV systems.
- Analyze the effect of irradiance, temperature, shading, and environmental conditions on solar PV performance.
- Evaluate maintenance procedures, inverter health, battery performance, and troubleshooting methods in solar systems.
- Create simple practical solutions or documentation for improving solar system performance via mini projects.

List of Practical

Perform 8 experiments, Experiment No 1, 2 and 10 are compulsory. Perform any 2 Experiments from 3 to 5. Perform any 3 Experiments from 6 to 9.

1. Measurement of solar irradiance using pyrometer/lux meter at different times and tilt angles. **Real-World Assignment**: Survey solar irradiance on the college rooftop and estimate daily energy generation for a 100 W solar panel.
2. Plot I-V and P-V characteristics of solar PV module under varying light & temperature. **Real-World Assignment:** Simulate cloudy/rainy day conditions. Calculate module efficiency and estimate annual energy loss in local area climate.
3. Survey and Comparative Analysis of Solar PV Installation Systems: Grid-Tied, Hybrid, and Off-Grid Configurations. **Real-World Assignment:** Survey 2–3 real solar installations (e.g., college rooftop, nearby home/business, or online/virtual)
4. Series and parallel connection of PV modules, observe mismatch issues. **Real-World Assignment**: Design a small array for 12V/24V system (e.g., for small electrical loads). Calculate total power and suggest suitable protection.
5. Installation and wiring of standalone solar PV system (PV > Charge controller > Battery > Load/Inverter) **Real-World Assignment**: Prepare a complete wiring diagram and BOM for a 100W standalone system.

6. Preventive maintenance: Cleaning, visual inspection, corrosion/loose connection check.
   Real-World Assignment: Inspect any existing rooftop solar panel installation. Prepare a 6-month maintenance schedule with cost estimation (dust cleaning, tightening).
7. Grid-Related Maintenance Checks for Grid-Tied Solar PV Systems: Inverter Health, Performance Monitoring, and Fault Diagnosis.
   Real-World Assignment: Survey a real grid-tied installation, Prepare a maintenance schedule: Monthly inverter check, quarterly visual, annual professional inspection.
8. Mounting structure assembly: Rooftop/ground mount, tilt adjustment, stability check
   Real-World Assignment: Design a simple mounting frame for local area wind load conditions. Calculate wind load and suggest material/cost for a 5kW residential installation.
9. IoT-Based Real-Time Solar PV System Monitoring and Performance Dashboard.
   Real-World Assignment: Develop a simple dashboard for real-time monitoring of solar energy generation.
10. Industrial Visit to Solar power plant/ solar installation in local area:
    Real-World Assignment: Prepare a technical report on solar PV system operation, maintenance practices, and safety measures.

Learning Resources

Text Books:

- S.P. Sukhatme, Solar Energy
- C.S. Solanki, Solar Photovoltaics
- D.P. Kothari et al., Renewable Energy Sources
- G.D. Rai, Non-Conventional Energy Sources
- H.P. Garg, Solar Energy Utilization

Reference Books:

- Solar Photovoltaic Technology and Systems: A Manual for Technicians, Trainers and Engineers Author:
- Solar PV System: Design, Installation, Operation and Maintenance, Authors: L. Ashok Kumar and K. Mohana Sundaram.
- Solar Engineering of Thermal Processes, Photo voltaics and Wind(5th Edition) Authors: JohnA. Duffie, William A. Beckman (updated with Nathan Blair).
- Principles of Solar Engineering (3rd Edition) Authors: D. Yogi Goswami, Frank Kreith, Jan F. Kreider

Links to online SWAYAM/NPTEL Courses

- Solar Photovoltaics: Fundamentals, Technology and Applications: https://onlinecourses.nptel.ac.in/noc
- Skill Cat or Other Free Solar Training (Installation Focus). https://www.skillcatapp.com/solarinstallation-training
- SWAYAM – Solar Energy and Solar PV Systems
- NPTEL – Power Electronics Applications in Renewable Energy Systems

Savitribai Phule Pune University
Third Year Chemical Engineering (2024 Pattern)
ELC-381-CEE - Internship/On Job Training (OJT)

Teaching Scheme	Credit	Examination Scheme
Practical: 08 Hours/Week	**04**	**Oral: 25 Marks** **Term work: 25 Marks**

Course Objectives:

The course aims to:

- Expose students to real-world chemical and process industry practices.
- Bridge the gap between theoretical concepts learned in chemical engineering courses and industrial applications.
- Develop professional ethics, safety awareness, communication skills, leadership, and teamwork.
- Enhance students' technical competency through hands-on exposure to industrial processes, equipment, analytical techniques, and process control systems.
- Encourage innovation, sustainability, entrepreneurship, research aptitude, and continuous improvement in chemical process industries.

Course Outcomes:

Upon successful completion of the course, students will be able to:

CO1: Apply chemical engineering fundamentals to analyse and solve practical industrial problems.

CO2: Demonstrate competency in industrial operations, process equipment, instrumentation, safety practices, quality systems, and process software.

CO3: Exhibit professional ethics, teamwork, communication skills, environmental responsibility, and industrial safety practices.

CO4: Prepare comprehensive technical reports and effectively present internship work using professional documentation practices.

CO5: Analyse industrial processes and recommend feasible improvements related to productivity, energy conservation, sustainability, process safety, waste minimization, and quality enhancement.

Guidelines

1. Students shall undergo a **technical internship** of **not less than 4 weeks** duration in a Chemical Engineering-related organization after completion of Semester V and before commencement of Semester VI.

2. The internship shall provide practical exposure to process industries, manufacturing operations, laboratory practices, process design, environmental engineering, energy management, research, or allied chemical engineering fields.

3. Participation only in classroom training or certificate courses shall **not** be considered as Internship, although such programs may supplement industrial learning. AICTE recommends internships that provide real industrial exposure and application of classroom knowledge.

4. Students shall undertake meaningful technical assignments involving process analysis, troubleshooting, experimentation, design assistance, quality control, process optimization, maintenance, safety, or research activities.

5. Students may also undertake projects involving data collection, experimental work, process simulation, process modelling, computational analysis, environmental monitoring, or industrial automation.
6. Internship organizations may include
   - Chemical Industries
   - Petrochemical Industries
   - Fertilizer Industries
   - Pharmaceutical Industries
   - Food and Bioprocess Industries
   - Polymer and Plastic Industries
   - Paint and Coating Industries
   - Sugar Industries
   - Paper and Pulp Industries
   - Oil & Gas Industries
   - Cement Industries
   - Water and Wastewater Treatment Plants
   - Pollution Control Organizations
   - Research Laboratories (CSIR, DRDO, BARC, NCL, ICT Mumbai, IITs)
   - Public Sector Undertakings
   - Process Equipment Manufacturers
   - Engineering Design & Consultancy Organizations
7. Before joining the internship, students shall submit
   - Synopsis
   - Permission Letter
   - Internship Offer Letter
8. Internship completion shall be considered only after submission of
   - Completion Certificate
   - Internship Report
   - Supervisor Feedback
   - Attendance/Logbook (where applicable)
   - Presentation and Viva-Voce
9. Students shall undergo evaluation through Term Work and Oral Examination.

Suggested Internship Activities

Phase I – Organization Familiarization

- Study of company profile
- Organization structure
- Manufacturing process overview
- Plant layout
- Safety induction
- Environmental management system
- Quality management system
- Standard Operating Procedures (SOPs)

Phase II – Process Learning

Students may study:

- Process Flow Diagram (PFD)
- Piping and Instrumentation Diagram (P&ID)
- Material and Energy Balance
- Heat Exchangers
- Reactors
- Distillation Columns
- Absorption and Extraction Units
- Pumps and Compressors
- Utilities
- Instrumentation and Process Control
- DCS/PLC Systems
- Laboratory Analytical Instruments
- Process Simulation (Aspen Plus, Aspen HYSYS, CHEMCAD, DWSIM, MATLAB)

Phase III – Technical Work

Students may undertake activities such as:

- Process Monitoring
- Production Planning
- Process Data Collection and Analysis
- Process Optimization
- Energy Audit
- Utility Management

- Waste Minimization
- Water Conservation
- Effluent Treatment Plant Study
- Air Pollution Control
- Process Safety Studies
- HAZOP/HAZID (where permitted)
- Risk Assessment
- Quality Assurance & Quality Control
- Laboratory Testing
- Maintenance Planning
- Preventive Maintenance
- Reliability Studies
- Lean Manufacturing
- Six Sigma
- Sustainability Assessment
- Carbon Footprint Analysis
- Research & Development
- Pilot Plant Studies
- AI/ML Applications in Process Industries
- Digitalization and Industry 4.0 Applications

Phase IV – Documentation and Presentation

- Preparation of Internship Report
- Technical Documentation
- Process Calculations
- Data Analysis
- Preparation of Process Flow Sheets
- Presentation Preparation
- Viva-Voce

Continuous Assessment Records

Students shall maintain

- Internship Joining Report

- Weekly Logbook
- Attendance Record
- Mid-Term Progress Report
- Industrial Supervisor Feedback
- Completion Certificate
- Internship Report
- Presentation Slides

Suggested Internship Domains

- Chemical Process Industries
- Petrochemical Engineering
- Fertilizer Industries
- Pharmaceutical Engineering
- Polymer Engineering
- Food and Bioprocess Engineering
- Environmental Engineering
- Water and Wastewater Engineering
- Oil & Gas Processing
- Process Design and Consultancy
- Process Equipment Design
- Industrial Automation
- Process Simulation
- Computational Chemical Engineering
- Artificial Intelligence in Chemical Engineering
- Process Data Analytics
- Energy Engineering
- Renewable Energy
- Green Chemical Engineering
- Circular Economy
- Carbon Capture and Utilization
- Industrial Safety Engineering
- Research & Development
- Entrepreneurship and Start-up Projects

Approved Internship Organizations

Students may undergo internship in

- Registered Chemical Industries
- Pharmaceutical Companies
- Petrochemical Industries
- Refineries
- Fertilizer Plants
- Sugar and Allied Industries
- Environmental Engineering Organizations
- Pollution Control Boards
- Research Institutes
- Government Organizations
- Public Sector Undertakings
- CSIR Laboratories
- IITs
- ICT Mumbai
- BARC
- NCL Pune
- Process Design Consultancies
- Chemical Equipment Manufacturing Industries

Note: Internships may be conducted in offline, online, or hybrid mode, subject to departmental approval and verification, consistent with AICTE internship guidelines.

Internship Report Format

Preliminary Pages

- Cover Page
- Certificate from Organization
- Certificate from Department
- Acknowledgement
- Abstract
- Table of Contents
- List of Figures
- List of Tables
- List of Symbols/Abbreviations

Chapter 1 – Organization Profile

- Company Overview
- Vision and Mission
- Products and Services

- Manufacturing Processes
- Organizational Structure
- Safety Practices
- Quality Certifications
- Environmental Policies

Chapter 2 – Project Definition

- Project Title
- Background
- Problem Statement
- Need of Project
- Objectives
- Scope

Chapter 3 – Methodology

- Process Description
- Process Flow Diagram
- Equipment Details
- Instrumentation
- Software Used
- Experimental Methodology
- Safety Measures

Chapter 4 – Work Carried Out

- Activities Performed
- Process Calculations
- Experimental Results
- Data Analysis
- Observations
- Challenges Faced
- Solutions Implemented
- Suggested Improvements

Chapter 5 – Learning Outcomes

- Technical Knowledge Gained
- Process Understanding
- Equipment Familiarity
- Laboratory Skills
- Professional Skills
- Teamwork

- Communication Skills
- Safety Awareness
- Sustainability Practices
- Future Scope

Chapter 6 – Conclusion

- Summary of Work
- Major Learning
- Achievements
- Recommendations
- Scope for Future Improvement

Reference Style to be used

- Elsevier, Wiley, ACS or Springer Reference Style (Preferred)

Appendices (in the report)

- Process Flow Diagrams
- P&IDs (where permitted)
- Experimental Data
- Calculations
- Process Photographs (where permitted)
- Certificates
- Supervisor Feedback
- Additional Documents

Recommended Text Books

1. W. J. King and James G. Skakoon, *The Unwritten Laws of Engineering*, ASME Press.
2. Stuart G. Walesh, *Engineering Your Future: The Professional Practice of Engineering*.
3. Eliyahu M. Goldratt, *The Goal: A Process of Ongoing Improvement*.
4. Coulson & Richardson's *Chemical Engineering*, Vols. 1–6.
5. Perry's *Chemical Engineers' Handbook*.
6. Sinnott & Towler, *Chemical Engineering Design*.
7. AICTE National Internship Portal.

Reference Books

1. Geankoplis, *Transport Processes and Separation Process Principles*.
2. Fogler, *Elements of Chemical Reaction Engineering*.
3. Smith, Van Ness & Abbott, *Introduction to Chemical Engineering Thermodynamics*.
4. Crowl & Louvar, *Chemical Process Safety: Fundamentals with Applications*.
5. Peters, Timmerhaus & West, *Plant Design and Economics for Chemical Engineers*.

TE – Chemical Engineering 2024 Pattern

National Education Policy (NEP)-2020 Compliant Syllabus

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