सावित्रीबाई फुले पुणे विद्यापीठ

Savitribai Phule Pune University, Pune, Maharashtra, India

Faculty of Science and Technology

National Education Policy (NEP)-2020 Compliant Curriculum

Second Year Engineering (2024 Pattern)
Chemical Engineering

(With effect from Academic Year 2025-26)

Preface by Board of Studies

Dear Students and Faculty,

We, the members of the Board of Studies in **Chemical and Petroleum Engineering**, are pleased to introduce the **Second Year Chemical Engineering** syllabus, effective from the **Academic Year 2025-26 (2024 Pattern)**. Chemical Engineering is a versatile and dynamic discipline that bridges the gap between molecular sciences and large-scale industrial processes. It encompasses the design, optimization, and operation of processes that transform raw materials into valuable products, playing a pivotal role in industries such as energy, pharmaceuticals, biotechnology, and environmental sustainability.

This curriculum has been meticulously designed to provide students with a strong foundation in core principles**,** hands-on laboratory experience, and industry-relevant problem-solving skills. The revised syllabus aligns with the objectives of NEP-2020**,** AICTE**,** UGC, and other accreditation bodies, ensuring that it meets global standards while addressing emerging technological advancements and industrial demands.

The syllabus includes enhanced pragmatic learning through laboratory work, simulations, and industry case studies without sacrificing rigor of a strong class-room based teaching and learning process. The other key features are the inherent flexibility of self-paced learning, encouraging students to pursue online courses, certifications, on-job training and research projects to deepen their knowledge in specialized areas.

We extend our sincere gratitude to faculty members, industry experts, students, and stakeholders for their valuable contributions in shaping this curriculum. Their insights have been instrumental in ensuring that this syllabus remains relevant, rigorous, and future-ready.

We hope this program will inspire students to explore the vast opportunities in Chemical Engineering and allied disciplines contributing meaningfully to technological and sustainable advancements.

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

Members of Board of Studies Chemical & Petroleum Engineering	
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Nomenclature

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

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

Second Year Engineering (2024 Pattern) – Chemical Engineering

Level 5.0															
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 I															
PCC-201-CEE	Program Core Course	Fluid Mechanics	3	-	-	30	70	-	-	-	100	3	-	-	3
PCC-202- CEE	Program Core Course	Process Calculations	3	-	-	30	70	-	-	-	100	3	-	-	3
PCC-203-CEE	Program Core Course	Applied Chemistry	3	-	-	30	70	-	-	-	100	3	-	-	3
PCC-204- CEE	Program Core Course	Applied Chemistry-Lab	-	-	4	-	-	25	50	-	75	-	-	2	2
PCC-205-CEE	Program Core Course	Fluid Mechanics - Lab	-	-	2	-	-	25	-	25	50	-	-	1	1
	Open Elective- I*		2	-	-	15	35	-	-	-	50	2	-	-	2
MDM-230-CEE	Multidisciplinary Minor - I	Engineering Mathematics III	2	-	-	30	70	-	-	-	100	2	-	-	2
EEM-240- CEE	Entrepreneurship/ Economics/ Management	Industrial Economics	-	1	2	-	-	25	-	-	25	-	1	1	2
VEC-250- CEE	Value Education	Universal Human Values and Professional Ethics	2	-	-	15	35	-	-	-	50	2	-	-	2
CEP-260-CEE	Community Engagement Project / Field Project	Process Safety Education	-	-	4	-	-	25	-	25	50	-	-	2	2
Total			**15**	**01**	**12**	**150**	**350**	**100**	**50**	**50**	**700**	**15**	**1**	**06**	**22**

* **Note:** Students can opt for Open Electives offered by different faculty like Arts, Science, Commerce, Management, Humanities or Inter-Disciplinary studies.
Example – Open Elective I - Financial Accounting, Digital Finance, Digital Marketing can be opted from Commerce and Management faculty.
And Elective II - Project Management, Business Analytical, Financial Management can be opted from Inter-Disciplinary studies, Commerce and Management faculty respectively

NEP 2020 Compliant Curriculum Structure

Second Year Engineering (2024 Pattern) – Chemical Engineering

Level 5.0															
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 II															
PCC-206-CEE	Program Core Course	Heat Transfer	3	-	-	30	70	-	-	-	100	3	-	-	3
PCC-207-CEE	Program Core Course	Materials and Design	3	-	-	30	70	-	-	-	100	3	-	-	3
PCC-208-CEE	Program Core Course	Mechanical Operations	2	-	-	30	70	-	-	-	100	2	-	-	2
PCC-209-CEE	Program Core Course	Heat Transfer – Lab	-	-	2	-	-	25	25	-	50	-	-	1	1
PCC-210-CEE	Program Core Course	Mechanical Operations-Lab	-	-	2	-	-	-	-	25	25	-	-	1	1
	Open Elective – II*		2	-	-	15	35	-	-	-	50	2	-	-	2
MDM-231-CEE	Multidisciplinary Minor - II	Introduction to Data Science	2	-	-	30	70	-	-	-	100	2	-	-	2
VSEC- 270-CEE	Vocational and Skill Enhancement Course	Chemical Engineering Skills	-	-	4	-	-	25	25		50	-	-	2	2
AEC-281-CEE	Ability Enhancement Course	Modern Indian Language (Marathi / Hindi)	-	1	2	-	-	50	-	-	50	-	1	1	2
EEM-241-CEE	Entrepreneurship/Economics/ Management	Chemical Industry Management	-	1	2	-	-	25	-	-	25	-	1	1	2
VEC-251-CEE	Value Education Course	Environmental Studies	2	-	-	15	35	-	-	-	50	2	-	-	2
Total			**14**	**02**	**12**	**150**	**350**	**125**	**50**	**25**	**700**	**14**	**02**	**06**	**22**

* **Note:** Students can opt for Open Electives offered by different faculty like Arts, Science, Commerce, Management, Humanities or Inter-Disciplinary studies.
Example – Open Elective I - Financial Accounting, Digital Finance, Digital Marketing can be opted from Commerce and Management faculty.
And Elective II - Project Management, Business Analytical, Financial Management can be opted from Inter-Disciplinary studies, Commerce and Management faculty respectively

Second Year Engineering
(2024 Pattern)

Chemical Engineering

(With effect from Academic Year 2025-26)

SEMESTER - I

Savitribai Phule Pune University

Second Year of Chemical Engineering (2024 Pattern)

Course Code: PCC-201-CEE Course Name: Fluid Mechanics

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

Prerequisite Courses, if any: Courses of Engineering Mathematics, Engineering Mechanics, Physics and Chemistry

Course Objectives:

The objective of the course is:

1. To introduce basic concepts of fluid mechanics, fluid properties, types of fluids and classification of flows.
2. To understand fluid statics, basic equations of fluid flow and applications to determine losses occurring through pipelines.
3. To develop relationships among process or system variables using dimensional analysis and fluidization and applications of different valves and pumps.

Course Outcomes:

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

CO1: State the fluid properties and understand the rheological behavior of fluids.

CO2: Use the equation of fluid statics and application of manometers for the pressure measurement

CO3: Relate basic equations of fluid flow and their applications to determine fluid flow rate by different devices.

CO4: Apply theorems to form mathematical equations and determine energy losses for flow of fluid through different system.

CO5: Understand concepts of boundary layer, fluidization and applications of different valves and pumps for transportation of fluid through pipelines.

Course Contents

Unit I	Properties of Fluids	(07 Hours)

Fluid, branches of fluid mechanics, properties of fluid, classification of fluids, different types of viscometers, Newton's law of viscosity, numerical, non-Newtonian fluids, types of flow, lines to describe the flow.

Unit II	Fluid Pressure and Measurement	(08 Hours)

Pascal's law, Hydrostatic law, concept of atmospheric, gauge, vacuum and absolute pressure, manometers, and pressure measurement by simple and differential manometer, Numerical based on manometers.

Unit III	Basic Equations of Fluid Flow and Flow Measuring Devices	(07 Hours)
Basic equations of fluid flow: continuity equation and equation of motion, flow measurement using venturi meter, orifice meter, pitot tube, rotameter, Mass flowmeters, Numerical on different flow measuring devices.		
Unit IV	**Fluid Flow through Pipelines and Dimensional Analysis**	**(08 Hours)**
Laminar flow through circular pipe: Hagen Poiseuille equation, major and minor losses, Darcy Weisbach equation, Numerical, dimensionless numbers in fluid mechanics, dimensional homogeneity, types of similarities, model and prototype, dimensional analysis by Rayleigh's method and Buckingham's method.		
Unit V	**Boundary Layer and Fluid Transportation**	**(08 Hours)**
Concept of hydrodynamic boundary layer, growth over a flat plate, different thickness of boundary layer, numerical based on boundary layer, types of fluidization, different types of valves and pumps, centrifugal pump working and characteristics, Numerical based on centrifugal pump.		

Learning Resources

Text Books:

1. Y. A. Cengel, J. M. Cimbala, "Fluid Mechanics: Fundamentals and Applications", McGraw Hill, 2017
2. L. P Modi, S. M. Seth, "Hydraulics and Fluid Mechanics", 22nd Edition, Standard Book House, 2019.
3. R. K. Bansal, "A Textbook of Fluid Mechanics and Hydraulic Machines", 9th Edition, Laxmi Publications, 2005.

Reference Books:

1. W. L McCabe, J. Smith, and P. Harriot, "Unit Operations of Chemical Engineering", McGraw Hill International Edition, 7th Edition, 2004.
2. Noel de Nevers, "Fluid Mechanics for Chemical Engineers", 3rd Edition; McGraw Hill, 2005.
3. M. Coulson, J.F. Richardson, with J.R. Backhurst and J.H. Harker, "Coulson, Richardson Chemical Engineering, Volume-1", 6th Edition., Butterworth-Heinemann,1999
4. F. W. White, "Fluid Mechanics", McGraw Hill, 9th Edition, 2022.

e-Books:

1. https://web.iitd.ac.in/~hirani/MEL311.pdf
2. https://engineeringbookslibrary.wordpress.com/wp-content/uploads/2019/03/fluid-mechanics-fundamentals-and-applications-3rd-edition-cengel-and-cimbala-2014.pdf
3. https://www.sciencedirect.com/book/9780081024379/introduction-to-fluid-mechanics

MOOC/NPTEL/YouTube Links:

1. **https://archive.nptel.ac.in/courses/127/103/127103225/**
2. **https://archive.nptel.ac.in/courses/103/102/103102211/**

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Second Year of Chemical Engineering (2024 Pattern)

Course Code: PCC-202-CEE Course Name: Process Calculations

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

Prerequisite Courses: Basics Mathematics, Applied Sciences, Momentum Transfer

Course Objectives:

The objective of the course is:

1. To develop ideas in dimensional analysis and to be familiar with different unit systems and conversion from one set of system to another.
2. To understand the various unit operations and unit processes performed in a chemical industry.
3. To learn fundamentals of stoichiometry and apply the material balance concept and precisely calculate the amount of materials required to carry out the suitable unit operation or process.
4. To learn the application of the general energy balance equation and precisely calculate the energy requirements of the unit operation or process involved.

Course Outcomes:

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

CO1: Apply the fundamental laws governing solid, liquid and gas phases.

CO2: Calculate the composition of materials.

CO3: Perform material balance with and without chemical reaction.

CO4: Perform material balance for various unit operations or processes in Chemical Engineering.

CO5: Calculate the energy requirement for various unit operations or processes in Chemical Engineering.

Course Contents

Unit I	Mathematical Principles	(08 Hours)

Introduction to unit processes and operations and their symbols, process flow sheet, Concept of steady and unsteady state operations, Units and dimensions: basic and derived units, different ways of expressing units and quantities, conversion of units, properties of pure substances, PVT behavior, ideal and real gas laws. Mole fractions and partial pressures, application of Dalton's, Amagat's, Henry's laws, concept of vapor pressure, Raoult's law and its applications, vapor pressure plots and effect of temperature on vapor pressure.

Unit II	Material Balance for Physical Systems	(08 Hours)

Concept, material balance calculations, recycling and bypassing operations, introduction to unsteady state

processes with examples like batch reactor, accumulation of inert components, application to various unit operations etc.

Unit III	Material Balance for Reacting Systems	(07 Hours)

Concept, material balance calculations, Definition of terms, chemical and electrochemical reactions, recycling parallel and bypassing operations

Unit IV	Energy Balance	(08Hours)

Concept, energy and Thermo chemistry, energy balances, heat capacity of pure substances and mixtures, latent heats, enthalpy of pure substances and mixtures, absolute enthalpy, heat of reaction, adiabatic reactions, thermo chemistry of mixing processes, dissolution, liquid-liquid mixtures, gas-liquid systems.

Unit V	Fuels and Combustion	(07 Hours)

Fuels, calorific values of fuels, coal, liquid fuels, gaseous fuels, air requirement and flue gases, combustion calculations.

Learning Resources

Text Books:

1. B.I. Bhatt and S. M. Vora, "Stoichiometry", 2nd Edition, Tata McGraw Hill, New Delhi, 2004
2. O. A. Hougen, R. M. Watson and R. A. Ragatz, "Chemical Process Principles Part I", 2nd Edition, CBS Publications, 1976.
3. K. V. Narayanan and B. Lakshmikutty, "Stoichiometry and Process Calculations", 2nd Edition, Prentice Hall of India, New Delhi, 2009.
3. V. Venkatramani, N. Ananatharaman, Sheriffa Begum, "Process Calculations", 2nd Edition, Prentice Hall of India, 2011.

Reference Books:

1. David M. Himmelblau, "Basic Principles and Calculations in Chemical Engineering", 8th Edition, Prentice Hall of India, New Delhi, 2012.
2. Richard M. Felder, Ronald W. Rousseau, "Elementary Principles of Chemical Processes", 3rd Edition, John Wiley and Sons, 2005.

e-Books:

1. **https://www.scribd.com/document/652405263/Stoichiometry-by-Bhatt-and-Vora-Copy**
2. **https://bietdvg.edu/media/department/BT/data/learning-materials/stoichometry1.pdf**
3. **https://www.ugierkl.ac.in/lecture_files/stoichiometry_1674023409_1675232674.pdf**

MOOC/NPTEL/YouTube Links:

1. **https://onlinecourses.nptel.ac.in/noc25_ch07/preview?user**
2. **https://archive.nptel.ac.in/courses/103/105/103105209/**
3. **https://onlinecourses.nptel.ac.in/noc22_ch02/preview**
4. **https://onlinecourses.nptel.ac.in/noc25_ch07/preview**

Savitribai Phule Pune University
Second Year of Chemical Engineering (2024 Pattern)
Course Code: PCC-203-CEE **Course Name: Applied Chemistry**

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

Prerequisite Courses: Fundamental understanding of different states of matter, atoms, elements, and molecules. Periodic table, types of chemical bonds, bond lengths, resonance, electronegativity, and bond polarity.

Course Objectives:

The objective of the course is:

1. To impart the basic concepts of Physical, Inorganic, Organic and Analytical chemistry
2. To develop understanding about concepts of organic reactions for the analysis of unit Processes
3. To study the different analytical instrumentation techniques

Course Outcomes:

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

CO1: Apply the principles of volumetric analysis to perform accurate titrations and concentration calculations.

CO2: Apply concepts of colligative properties and thermodynamics to interpret the behavior of ideal and non-ideal solutions.

CO3: Apply structural and electronic concepts to predict the behavior of heterocyclic compounds and classify dyes based on chemical constitution.

CO4: Understand coordination chemistry concepts and crystal field theory to explain the properties and structures of transition metal complexes.

CO5: Evaluate data from chromatography, spectroscopy, and electron microscopy for material characterization

Course Contents

Unit I	Volumetric Analysis	(06 Hours)

Introduction to standard solutions, primary and secondary standard substances, and methods for accurate preparation and standardization, various units of concentration, including molarity, normality, molality, parts per million (ppm), and weight/volume percent, with relevance to small-scale and industrial chemical processes. Types of titrations-neutralization (with titration curves), complexometric, redox and precipitation with examples. Theory of indicators in above titrations. Numerical on all above.

Unit II	Colligative Properties	(07 Hours)

Solution: -definition, solution of gas in gas, gases in liquid, Henry's law, the ideal solution, Raoult'1s law of ideal solution, solutions of liquids in liquids, theory of dilute solution. Colligative properties, Definition of osmosis & osmotic pressure, Colligative properties of dilute solution- lowering of vapor pressure, elevation of boiling point and thermodynamic derivation, depression in freezing point and thermodynamic derivation. Abnormal behaviour of solutions of electrolytes, Van't Hoff factor. Numerical on all above.

Unit III	Heterocyclic compounds and Dyes	(08 Hours)

Aromaticity, preparation, reactions of pyrrole, furan, and pyridine. Dyes- Nomenclature, methods of application, color and chemical constitution (chromophoreauxochrome theory), classification of dyes on the basis of chemical structure, diazotization and coupling for azo dyes, synthesis of Sudan I, alizarin, methyl orange, phenolphthalein.

Photochemical and advanced methods of dye degradation.

Unit IV	Transition metals and Co-ordination Chemistry	(08 Hours)

Electronic configuration of first series transition metals shapes of d- orbital characteristics (variable oxidation states, magnetic property, color of transition metal compounds). Ligands, C.N. and geometry, nomenclature of complexes, chelates. Theories of co-ordination- i) Werner ii) EAN iii) CFT (including crystal field splitting in octahedral field and tetrahedral field, CFSE for octahedral complexes, applications of CFT). Transition metal complexes, Applications in Chemical Industry. Hydroformylation using catalyst, coordination catalysts in Wacker's process.

Unit V	Instrumental methods of Analysis and Interface Chemistry	(08 Hours)

Chromatography: principle, instrumentation and applications of TLC, column, Gas Chromatography and HPLC, IR spectroscopy-introduction, instrumentation, applications, Flame photometry- principle, instrumentation and applications, Scanning Electron Microscopy (SEM)- principle, instrumentation and applications.

Interface Chemistry: Adsorption, Introduction to Freundlich and Langmuir theories of adsorption, adsorption from solution, B.E.T. Theory of adsorption of gases, Application of adsorption, numerical on above.

Learning Resources

Reference Books:

1. J. D. Lee, "Inorganic Chemistry", John Wiley & Sons, 5th Edition, 2012.
2. P. L. Soni, O. P. Dharmarha, U. N. Dash, "Textbook of Physical Chemistry", Sultan Chand & Sons, 2011.
3. P.W. Atkins, "Physical Chemistry", Oxford University Press, 10th Edition, 2014
4. R. Chatwal and S. Anand, "Instrumental Methods of Chemical Analysis", Himalaya Publishing House, 5th Edition, 2009

5. G.D. Christian, “Analytical Chemistry”, John Wiley & Sons, 7th Edition, 2003
6. J. March, “Reaction Mechanism in Organic Chemistry”, John Wiley & Sons, 7th Edition, 2013
7. H.H. Willard, L.L. Merritt, J.A. Dean and F.A. Settle, “Instrumental Methods of Analysis”, CBS Publishers, 7th Edition, 1988
8. J. Clayden, N. Greeves, and S. Warren, “Organic Chemistry”, Oxford University Press, 2nd Edition, 2012.

e-Books:

1. **http://books.ms/main/7130732302D61A1897E4AA38E0E06B9F**
2. **http://books.ms/main/C6BD050597D434C3CBC0CE0C6869CDFC**
3. **http://books.ms/main/EAB75A8D6982A2D79CD8DE039700B6A5**
4. **http://books.ms/main/D2ABAFF30DAF607DA89898196EB50E7A**
5. **http://books.ms/main/F5D731FC6ED5F095C530DA0C28C040AD**

MOOC/NPTEL/YouTube Links:

1. **https://www.youtube.com/playlist?list=PL_A4M5IAkMadkjXXk9EiOUrn1lGbBico_**
2. **https://archive.nptel.ac.in/courses/104/106/104106119/**
3. **https://onlinecourses.nptel.ac.in/noc22_cy02/preview**
4. **https://onlinecourses.nptel.ac.in/noc20_cy18/preview**
5. **https://www.mooc-list.com/tags/physical-chemistry**

Savitribai Phule Pune University
Second Year of Chemical Engineering (2024 Pattern)
Course Code: PCC-204-CEE **Course Name: Applied Chemistry-Lab**

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

Prerequisite Courses: Basic understanding of Chemistry, Basic Sciences and Elementary Mathematics

Course Objectives:

The objective of the course is:

1. To train the students to do volumetric analysis.
2. To train the students estimation of various important parameters through experimentation.
3. To make the students aware of identification of compounds based on functional groups.
4. To synthesize various organic compounds.
5. To aware students for the importance of chemistry in Chemical Engineering

Course Outcomes:

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

CO1: Apply the principles of volumetric analysis to perform accurate titrations and concentration calculations.

CO2: Apply concepts of colligative properties and thermodynamics to interpret the behavior of ideal and non-ideal solutions.

CO3: Synthesize various important organic compounds.

CO4: Measure or estimate various important physico-chemical properties.

CO5: Develop in-depth knowledge of physical, organic, inorganic chemistry to be applied to chemical processes.

List of Laboratory Experiments (Any 12 experiments from the given list)

Any SIX experiments from serial number 1 – 13

1) Determination of chloride content in solution by Mohr's method.
2) To determine rate constant of first order reaction of acid catalysed hydrolysis of ester
3) Estimation of Alkali content in Antacid using HCl.
4) Preparation of benzoic acid from benzamide, crystallization and purity checking by TLC.
5) Preparation of aspirin from salicylic acid.
6) Preparation of nitrobenzene Sulphonation of benzene/toluene

7) Preparation of Glucosazone derivative of Glucose.

8) Preparation of Paracetamol from p-Aminophenol.

9) Determination of Diameter of solute molecule by viscosity measurements.

10) Determination of molecular weight of solid by Elevation in Boiling Point.

11) Determination of molecular weight of solute by depression in freezing point of solvent.

12) To investigate the rate constant of an autocatalytic reaction between potassium permanganate and oxalic acid.

13) Analysis of Calcium from milk powder

14) Identification of given organic compound (with maximum one functional group) Systematic analysis (**Minimum THREE compounds**)

15) Adsorption of acetic acid on charcoal to verify Freundlich isotherm.

Must Perform any TWO experiment from 16 to 19

16) Preparation of tris ethylene diammine nickel (II) thiosulphate

17) Preparation of tetramine copper (II) sulphate, pot. trioxalato aluminate

18) Preparation of tris(glycinato)nickelate(II), $[Ni(gly)_3]^-$

19) Preparation of hexamminenickel(II) chloride, $[Ni(NH_3)_6]Cl_2$.

20) Preparation of Sudan I dye

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

• All the experiments (Any Eight) mentioned in the syllabus are compulsory.

• 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:

1. J. D. Lee, "Inorganic Chemistry", John Wiley & Sons, 5th Edition, 2012.
2. P. L. Soni, O. P. Dharmarha, U. N. Dash, "Textbook of Physical Chemistry", Sultan Chand & Sons, 2011.
3. P.W. Atkins, "Physical Chemistry", Oxford University Press, 10th Edition, 2014
4. R. Chatwal and S. Anand, "Instrumental Methods of Chemical Analysis", Himalaya Publishing House, 5th Edition, 2009
5. G.D. Christian, "Analytical Chemistry", John Wiley & Sons, 7th Edition, 2003
6. J. March, "Reaction Mechanism in Organic Chemistry", John Wiley & Sons, 7th Edition, 2013
7. H.H. Willard, L.L. Merritt, J.A. Dean and F.A. Settle, "Instrumental Methods of Analysis", CBS Publishers, 7th Edition, 1988
8. J. Clayden, N. Greeves, and S. Warren, "Organic Chemistry", Oxford University Press, 2nd Edition, 2012.

e-References:

1. **https://www.vlab.co.in/broad-area-chemical-sciences**
2. **http://books.ms/main/7130732302D61A1897E4AA38E0E06B9F**
3. **http://books.ms/main/C6BD050597D434C3CBC0CE0C6869CDFC**

Savitribai Phule Pune University

Second Year of Chemical Engineering (2024 Pattern)

Course Code: PCC-205-CEE **Course Name: Fluid Mechanics-Lab**

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

Prerequisite Courses, if any: Courses of Engineering Mathematics, Engineering Mechanics, Physics and Chemistry

Course Objectives:

The objective of the course is:

1. To train the students to do observe and analyze fluid flow operations.
2. To train the students perform systematic experimentation.
3. To make the students aware of various fluid measuring devices and their application.
4. To understand various losses during fluid movement.
5. To verify various laws and principles of fluid flow.

Course Outcomes:

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

CO1: Understand rheological behavior of fluids and its measurement.

CO2: Experimentally verify various laws and equations governing fluid flow operation.

CO3: Determine fluid flow rate by different devices.

CO4: Understand the characteristic of centrifugal pump.

CO5: Understand concepts of fluidization, governing equation and its applications.

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

1) Determination of viscosity
2) Reynolds experiment to determine laminar and turbulent flow
3) Bernoulli's theorem
4) Flow through venturi meter
5) Flow through orifice meter
6) Flow through rotameter
7) Study on Major losses
8) Study on Minor losses
9) Characteristics of centrifugal pump
10) Verification of stokes law

11) Flow through 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

• All the experiments (Any Eight) mentioned in the syllabus are compulsory.

• Use of open source software and recent version can be used.

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. Y. A. Cengel, J. M. Cimbala, "Fluid Mechanics: Fundamentals and Applications", McGraw Hill, 2017
2. W. L McCabe, J. Smith, and P. Harriot, "Unit Operations of Chemical Engineering", McGraw Hill International Edition, 7th Edition, 2004.

3. F. W. White, “Fluid Mechanics”, McGraw Hill, 9th Edition, 2022.
4. Noel de Nevers, “Fluid Mechanics for Chemical Engineers”, 3rd Edition; McGraw Hill, 2005.

e-References:

1. **https://fm-nitk.vlabs.ac.in/**
2. **https://me.iitp.ac.in/Virtual-Fluid-Laboratory/**
3. **https://web.iitd.ac.in/~hirani/MEL311.pdf**

Savitribai Phule Pune University
Second Year of Chemical Engineering (2024 Pattern)
Multidisciplinary Minor - I
Course Code: MDM-230-CEE Course Name: Engineering Mathematics-III

Teaching Scheme	Credit	Examination Scheme
Theory: 02 Hours/Week	**02**	**CCE: 30 Marks** **End-Semester: 70 Marks**

Prerequisite Courses, if any: Differential & Integral calculus, Linear Differential equations of first order and first degree, Collection, classification & representation of data.

Course Objectives:

The objective of the course is:

1. To familiarize the students with concepts and techniques in Ordinary differential equations
2. To apply statistical methods, probability theory
3. To solve Algebraic & Transcendental equations through Numerical techniques.
4. To develop concepts of numerical differentiation and integration, numerical solutions of ordinary differential equations.
5. To equip students with 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 Higher order linear differential equations and its applications to chemical engineering problems.

CO2: Apply Statistical methods like correlation & regression and probability theory as applicable to analyzing and interpreting experimental data applicable to chemical engineering problems.

CO3: Solve Algebraic & Transcendental equations and System of linear equations using numerical techniques.

CO4: Obtain Interpolating polynomials, numerical differentiation and integration, numerical solutions of ordinary differential equations used in dynamic chemical processes.

CO5: Apply Integral transform techniques such as Laplace transform to solve differential equations in chemical engineering applications.

Course Contents

Unit I	Linear Differential Equations (LDE) and Applications	(06 Hours)

LDE of nth order with constant coefficients, Complementary Function, Particular Integral, Method of Variation of parameters, Cauchy's and Legendre's DE, Simultaneous DE. Applications of LDE to Chemical engineering problems.

Unit II	Statistics and Probability	(06 Hours)

Measures of central tendency, Measures of dispersion, Coefficient of variation, Moments, Skewness and Kurtosis, Correlation and Regression, Reliability of Regression estimates. Probability, Probability density function, Probability distributions: Binomial, Poisson, Normal, Test of hypothesis: Chi-square test.

Unit III	Numerical Methods for solving Algebraic and Transcendental Equations	(06 Hours)
Numerical Solution of Algebraic and Transcendental equations: Bisection, Secant, Regula-Falsi, Newton–Raphson and Successive Approximation Methods, Convergence and Stability. Numerical Solutions of System of linear equations: Gauss elimination with partial pivoting, LU Decomposition, Jacobi and Gauss-Seidel Methods.		
Unit IV	**Numerical Interpolation and Solution of ODE**	**(06 Hours)**
Interpolation: Finite Differences, Newton's and Lagrange's Interpolation formulae, Numerical Differentiation. Numerical Integration: Trapezoidal and Simpson's rules, Bound of truncation error. Solution of Ordinary differential equations (ODE): Euler's, Modified Euler's, Runge-Kutta 4th order methods and Predictor-Corrector methods		
Unit V	**Laplace Transform (LT) and Applications**	**(06 Hours)**
Laplace Transform (LT): Definition of LT, Inverse LT, Properties & theorems, LT of some special functions viz. Periodic, Unit Step, Unit Impulse, Error, Si(t) and Ei(t). 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).		

Learning Resources

Text Books:

1. B.V. Ramana, "Higher Engineering Mathematics", Tata McGraw-Hill, New Delhi, 2017.
2. B. S. Grewal, "Higher Engineering Mathematics", Khanna Publishers, New Delhi, 2015.

Reference Books:

1. Erwin Kreyszig, "Advanced Engineering Mathematics," 10th Edition, by Wiley India, 2006.
2. Michael D. Greenberg, "Advanced Engineering Mathematics, 2nd Edition, Pearson Education, 1998.
3. Peter V. O'Neil, "Advanced Engineering Mathematics", 8th Edition, Cengage Learning, 2023.
4. Shepley L. Ross, "Differential Equations", 3rd Edition, Wiley India, 2018.
5. Sheldon M. Ross, "Introduction to Probability and Statistics for Engineers and Scientists", 6th Edition, Elsevier Academic Press, 2021.

e-Books:

1. **https://archive.org/details/higher-engineering-mathematics-bs-grewal**
2. **https://wp.kntu.ac.ir/dfard/ebook/em/Advanced%20Engineering%20Mathematics%2010th%20Edition.pdf**
3. **https://minerva.it.manchester.ac.uk/~saralees/statbook3.pdf**
4. **https://plcsitemiz.files.wordpress.com/2009/04/the-laplace-transform-theory-and-applications.pdf**

MOOC/NPTEL/YouTube Links:

1. **https://archive.nptel.ac.in/courses/122/107/122107037/**
2. **https://archive.nptel.ac.in/courses/111/105/111105041/**
3. **https://archive.nptel.ac.in/courses/111/107/111107107/**
4. **https://archive.nptel.ac.in/courses/111/106/111106139/**

Savitribai Phule Pune University

SE Chemical Engineering (2024 Pattern)

Course Code: EEM-240-CEE Course Name: Industrial Economics

Teaching Scheme	Credit	Examination Scheme
Tutorial: 01 Hour/Week **Practical: 02 Hours/Week**	**01** **01**	**Term Work: 25 Marks**

Course Objectives:

The objective of the course is:

1. To develop an insight in various Chemical plant Cost engineering using fundamental concepts of cost analysis.
2. To provide adequate background of Mathematics to deal with Cost Estimation Problems
3. To understand cost reduction due to depreciation using standard world -wide methods
4. To study cost indexes and equipment capacity evaluation using thumb rules.
5. To know project management methods using project networking analysis.

Course Outcomes:

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

CO1: Understand the basic principles of process economics, costing and depreciation of process equipment.

CO2: Evaluate the knowledge of cost estimation through Capital Investment, Cost Indexes and capacity of process equipment.

CO3: Apply the methods of capital investments and evaluate the total product cost of product

CO4: Trained to perform project scheduling and profitability analysis.

CO5: Perform networking of the project using PERT and CPM Techniques.

Course Contents

Unit I	Cost Engineering	(03 Hours)

Time value of money and equivalence, interest-simple, compound and continuous, present worth and discount, annuities, perpetuities and capitalized cost methods, depreciation, nature of depreciation, methods of determining depreciation – Straight Line, Sum-of-the-years-digits, Sinking find, declining balance method, double declining balance method.

Unit II	Cost Estimation	(03 Hours)

Cash flow for industrial operations, cumulative cash position of cash flow for an industrial operation, capital investments, fixed capital cost, working capital cost, start-up costs, process equipment cost estimation, cost index and its types, Six-tenth factor rule.

Unit III	Capital Investment, Taxes and Insurances	(03 Hours)

Methods of estimating capital investment, estimation of plant cost, estimation of total product cost, manufacturing cost, general expenses. Break-even chart, Break-even points- In value and points. Taxes and insurances, types of taxes and insurances, procedure for cost comparison after taxes.

Unit IV	Project Scheduling and Profitability	(03 Hours)

Role of project engineering in project organization, process engineering: Plant location, Plant Lay outs, Unit plot plans, scheduling the project; the feasibility report.
Profitability: Criteria of profitability, payout period, return on investment, present value, cash flow analysis, alternative investment analysis

Unit V	Networking of Projects	(03 Hours)

Critical path method (CPM): events and activities; network diagramming; earliest start time and earliest finish time; latest start time and latest finish time; float, advantage of CPM; cost to finish the projects earlier than normal cost; precedence diagramming. program evaluation and review technique (PERT): pert network and time estimates.

List of Assignments (Any 5 assignments from the given list)

Tutorials/Assignments

Guidelines:

- **Based on group of five students or the practical batch the problem values can be changed for the same numerical and assessed accordingly.**
- **Each student has to solve <u>any FIVE tutorials</u> out of the listed below**

- **Types of problems**

Problems can be based on –

1. Evaluation and comparison of Simple, compound and continuous interests values for same principal amount.
2. Estimation of present worth, annuity and discount
3. Evaluation and comparison of depreciation values by straight line, sum-of-the-years-digits, sinking fund and double declining balance methods for same principal value
4. Estimation of Equipment capacity based on six-tenth factor rule and cost index in two different years
5. Evaluation of profitability based on Payout period and return on investment
6. Comparison of profitability based on Return of investment method
7. Study of PERT and CPM method
8. Calculation of earliest start time and earliest finish time; latest start time and latest finish time; float and slack variable

Learning Resources

Text Books:

1. M. S. Peters and K. D. Timmerhaus, “Plant Design and Economics for Chemical Engineers”, Mc Graw Hill, 2002.

2. Richard Turton, R.C. Bailie, W.B. Whiting, J.A. Shaeiwitz, "Analysis, Synthesis and Design of Chemical Processes", 4th Edition, Prentice Hall, 2012.

Reference Books:

1. R.K Sinnot,"Coulson & Richardson's Chemical Engineering- Chemical Engineering Design", Vol. 6, Butterworth-Heinemann,
2. L. S. Srinath, "PERT AND CPM." affiliated East Press Pvt. Ltd., New York, 1973
3. J. H. Perry (Editor) "Chemical Engineering Handbook" 7th Edition, McGraw Hill, 1997

e-Books:

1. **https://ptgmedia.pearsoncmg.com/images/9780132618120/samplepages/0132618125.pdf**
2. **https://dl.icdst.org/pdfs/files1/09f2516ecf28dd4b294b160fb9527043.pdf**
3. **https://www.sciencedirect.com/science/article/pii/S157079460180170X**

MOOC/NPTEL/YouTube Links:

1. **https://archive.nptel.ac.in/courses/103/105/103105166/**
2. **https://archive.nptel.ac.in/courses/103/103/103103039/**
3. **https://nptel.ac.in/courses/103105166**

Savitribai Phule Pune University

SE Chemical Engineering (2024 Pattern)

Course Code: VEC-250-CEE
Course Name: Universal Human Values and Professional Ethics

Teaching Scheme	Credit	Examination Scheme
Theory: 02 Hours/Week	02	CCE: 15 Marks End Sem Exam: 35 Marks

Course Objectives:

The objective of the course is:

1. To help the students appreciate the essential complementarity between values and skills to ensure mutual happiness and prosperity.
2. To elaborate on 'Self-exploration' as the process for Value Education.
3. To facilitate the understanding of harmony at various levels starting from self and going towards family and society.
4. To elaborate on the salient aspects of harmony in nature and the entire existence.
5. To explain how the Right understanding forms the basis of Universal human values and definitiveness of Ethical human conduct.
6. To provide the vision for a holistic way of living and facilitate transition from chaotic life to an orderly life.

Course Outcomes:

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

CO1: Recognize the concept of self-exploration as the process of value education

CO2: Interpret the human being as the coexistence of self and body.

CO3: Explain relationship between oneself and the other self as the essential part of relationship and harmony in the family.

CO4: Interpret the interconnectedness, harmony and mutual fulfilment inherent in nature and the entire existence.

CO5: Draw ethical conclusions in the light of Right understanding facilitating the development of holistic technologies production systems and management models.

Course Contents

Unit I	Introduction to Value Education	(06 Hours)

Understanding Value Education, Self-exploration as the Process for Value Education, Continuous Happiness and Prosperity - the Basic Human Aspirations and their Fulfilment, Right Understanding, Relationship and Physical Facility, Happiness and Prosperity - Current Scenario, Method to Fulfil the Basic Human Aspirations.

Unit II	Harmony in Human Being	(06 Hours)

Understanding Human being as the Co-existence of the Self and the Body, distinguishing between the Needs of the Self and the Body, The Body as an Instrument of the Self, Understanding Harmony in the Self, Harmony of the Self with the Body, Program to Ensure self-regulation and Health.

Unit III	Harmony in Family and Society	(06 Hours)
Harmony in the Family - the Basic Unit of Human Interaction "Trust' - the Foundational Value in Relationship, 'Respect' - as the Right Evaluation, Values in Human-to-Human Relationship, Understanding Harmony in the Society, Vision for the Universal Human Order.		
Unit IV	**Harmony in the Nature (Existence)**	**(06 Hours)**
Understanding Harmony in the Nature, Interconnectedness, self-regulation and Mutual Fulfilment among the Four Orders of Nature, Realizing Existence as Co-existence at All Levels, The Holistic Perception of Harmony in Existence.		

List of Assignments (Any 8 Assignments from the given list)

Guidelines for continuous assessment:
Considering the specific nature of this course, the methodology is exploration based and thus universally adaptable. In order to connect the content of this course with practice, minimum two group activities must be conducted with active involvement of the students. 50 % of the continuous assessment should be strictly based on the participation of the students in the following activities.

Perform any eight (three experiments should be on bread board/trainer kit) experiment from following list:

1. Assignment 1: Sharing about Oneself
Introduction of students with following points yourself, family, friends, achievements and failures, your aspirations from life. How do you expect to fulfil these aspirations and live a life of fulfilment?
Expected Outcome: The students start exploring themselves; get comfortable with each other and with the teacher and start appreciating the need and relevance of the course.

2. Assignment 2: Exploring Human Consciousness
Watch and discuss the documentary video "Story of Stuff" It is about materials economy – its motivation, process and outcome. (Source: http://storyofstuff.org/movies/story-of-stuff)
Expected Outcome: The students start finding that right understanding is the basic need of human being; followed by relationship and physical facility. They also start feeling that lack of understanding of human values is the root cause.

3. Assignment 3: Exploring right understanding
Make a list of your desires. Now for each item on the list, find out what would be necessary to fulfil it, i.e. will it require: (a) Right understanding? (b) Relationship (right feeling)? (c) Physical facility?
Expected Outcome: Students start feeling that lack of understanding of human values is the root cause of all problems and the sustained solution could emerge only through understanding of human values and value-based living.

4. Assignment 4: Exploring Natural Acceptance
Observation within faculty of 'Natural Acceptance', based on which you can verify what is right or what is not right for you. Make a list of the problems in your family. For each problem, find out the most significant reason: is it related to lack of right understanding, lack of feelings in relationship or lack of physical facility?
Also, find out how much time and effort you have devoted for each in the last one week.
Expected Outcome: The students are able to see that self-verification must be based on their natural acceptance. In many cases, their actual living is not in accordance with their natural acceptance. In

addition, lack of feeling in relationship is the major cause of problems in their family and with friends.

5. Assignment 5: Exploring the difference of Needs of Self and Body
Take the list of desires you made in Practical 2. Update it if required. Now classify the desires as being related to the need of the Self or need of the Body.
Expected Outcome: The students are able to relate their desires to need of the Self and the Body distinctly. They are able to see that the Self and the Body are two distinct realities, and large parts of their desires are related to the need of the Self (and not the Body).

6. Assignment 6: Exploring Sources of Imagination in the Self
Recall the times that your body has been ill (in disharmony) in the last 3 years. What steps were taken to restore the harmony of the Body? If you were to take full responsibility for your body, (i.e. you had the feeling of self-regulation), what kind of daily schedule would you have? Approximately how much time would you allocate for keeping your body in good health?
Expected Outcome: The students are able to list down activities related to proper upkeep of the Body and practice them in their daily routine. They are also able to appreciate the plants growing in and around the campus, which can be beneficial in maintaining their health and even curing common ailments.

7. Assignment 7: Exploring the Feeling of Trust
Show and discuss the video "Right Here Right Now". It is a short film directed by Anand Gandhi about human behavior and its propagation.
(Source: Part 1: https://www.youtube.com/watch?v=OVAokeqQuFM
Part 2: https://www.youtube.com/watch?v=gIYJePEnvUY).
Expected Outcome: The students are able to see that the natural acceptance (intention) of everyone is to be happy and make others happy! It is the competence is lacking in themselves and in others. They are able to distinguish between reaction and response, appreciate the need for 100% response in human-human interaction and make effort towards it.

8. Assignment 8: Exploring the Feeling of Respect
List out ten or more of your interactions with other people in your family and friends in the last one week. Now analyse these interactions were over-evaluation, under/ otherwise evaluation or right evaluation of the other? In each interaction, were you comfortable within, uncomfortable within or unaware of your state?
Expected Outcome: The students are able to see that respect is the right evaluation (of intention and competence). Only right evaluation leads to fulfilment in relationship. Over evaluation leads to ego and under/otherwise evaluation leads to depression.

9. Assignment 9: Exploring Systems to fulfil Human Goal
Assuming that you would like to see your hostel/ educational institution/ workplace/ neighbourhood as a model of human society, write down its goal(s) and the system to achieve these goals.
Expected Outcome: The students are able to see that as a family, a society, the comprehensive human goal is naturally acceptable to all.
They are able to see that the systems required for their fulfilment include; Education-Sanskar, Health-Self regulation, Production-Work, Justice-Preservation and Exchange-Storage.
Meaningful participation by every individual, every family, every family cluster … every village, town city … and the whole world is required in this systems for the human goals to be fulfilled.

10. Assignment 10: Exploring the Four Orders of Nature
Watch and discuss the documentary video 'An Inconvenient Truth', It is about global climate change presented by former US Vice-President Al Gore. He raises the question "What were you doing when you had time to do something?" (Source: http://an-inconvenient-truth.com/)

Expected Outcome: The students are able to appreciate the interconnectedness, interdependence and the relationship of mutual fulfilment existing in nature. They are able to see that they have a natural acceptance to participate in a mutually fulfilling manner in nature.

11. Assignment 11: Exploring Co-existence in Existence

Observe yourself. Are you in space? Are you getting energy from the body? Is your energy dependent on the body? When your body is sick, does your energy to think diminish? Are you energized in space? Is the body dictating to you? Are you self-organized in space?

Expected Outcome: The students are able to obtain a holistic vision about the existence. It is in the form of co-existence, rather than chaos. Every unit is energized, self-organised and is participating with other units in an orderly manner for mutual fulfilment. It is only the human being without right understanding, which is violating this underlying co-existence. They are able to appreciate the need to understand the co-existence in Existence.

Learning Resources

Text Books:

1. R R Gaur, R Asthana, G P Bagaria, "The Textbook-A Foundation Course in Human Values and Professional Ethics", 3rd Revised Edition, Excel Books, New Delhi, 2019.
2. R R Gaur, R Asthana, G P Bagaria, "The Teacher's Manual for a Foundation Course in Human Values and Professional Ethics", 2nd Revised Edition, Excel Books, New Delhi, 2019.

Reference Books:

1. P. L. Dhar, R. R. Gaur, "Science and Humanism, Commonwealth Publishers A Jaico and Charles H. Roth, "Fundamentals of Logic Design", 4th Edition, 1990.
2. A. Nagaraj, "Jeevan Vidya: Ek Parichaya", Jeevan Vidya Prakashan, Amarkantak, 1999.
3. B. P. Banerjee, "Foundations of Ethics and Management", Excel Books, 2005.
4. A. N. Tripathy, "Human Values", New Age International Publishers, 2003.
5. E. G. Seebauer & Robert L. Berry, "Fundamentals of Ethics for Scientists and Engineers", Oxford University Press, 2000.
6. B. L. Bajpai, "Indian Ethos and Modern Management", New Royal Book Co., Lucknow, 2008.
7. M. Govindrajran, S Natrajan and V.S. Senthil Kumar, "Engineering Ethics and Human Values, Eastern Economy Edition", Prentice Hall of India Ltd.
8. M K Gandhi, "The Story of My Experiments with Truth", Jaico Publishing House, 2008.

e-Resource:

1. https://fdp-si.aicte-india.org/download.php#1/
2. http://madhyasth-darshan.info/postulations/knowledge/knowledge-of-humane-conduct/
3. https://www.youtube.com/channel/UCQxWr5QB_eZUnwxSwxXEkQw

MOOC/NPTEL/YouTube Links:

1. MPTEL Course on "Exploring Human Values: Visions of Happiness and Perfect Society" by Prof. A. K. Sharma, Department of Humanities and Social Sciences, IIT Kanpur, https://nptel.ac.in/courses/109104068

Savitribai Phule Pune University

SE Chemical Engineering (2024 Pattern)

Course Code: CEP-260-CEE Course Name: Process Safety Education

Teaching Scheme	Credit	Examination Scheme
Practical: 04 Hours/Week	**02**	**Term Work: 25 Marks** **Oral: 25 Marks**

Course Objectives:

The objective of the course is:

1. To understand the importance of safety.
2. To learn about industrial hygiene and regulations on safety in process industry.
3. To develop idea on flammability limits and fire triangle.
4. To learn about sustainable development and its importance in environmental conservation.
5. To develop collaboration skills to work with others on environmental projects.

Course Outcomes:

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

CO1: Develop a sense of environmental responsibility and stewardship.

CO2: Develop an appreciation for nature and its importance in human well-being.

CO3: Perform the work studies for sustainability and environmental conservation.

CO4: Design to prevent fires and explosions in real-world situations.

CO5: Perception on HAZOP and fault tree analysis.

Course Contents

Unit I	Safety and Toxicity Limits	(03 Hours)

Concepts and definition, safety culture, storage of dangerous materials, plant layout safety systems, the accident process: Initiation, propagation, and termination, toxicology: ingestion, inhalation, injection, relative toxicity, threshold limit values.

Unit II	Safety in Process Industries	(03 Hours)

Industrial hygiene: government regulations, identification, evaluation: evaluating exposures to volatile toxicants by monitoring, evaluating worker exposures to dusts, evaluating worker exposures to noise, estimating worker exposures to toxic vapors.

Unit III	Flammability and Fire Triangles	(03 Hours)

Scale of disaster, fire triangle, distinction between fires and explosion, fire point, flammability limits, mechanical explosion deflagration and detonation, confined explosion, unconfined explosion, vapor cloud explosions, boiling liquid expanding vapor explosion (BLEVE), flammability characteristics of liquids and vapors, minimum oxygen concentration (MOC).

Unit IV	Preparedness Handling Hazards	(03 Hours)
Control of toxic chemicals, Storage and handling of flammable and toxic chemical, Runway reactions, Relief system risk and hazards management, Design to prevent Fires and Explosions: Injecting Inert, static Electricity, Explosion proof equipment and Instrument, Ventilation, sprinkler systems and Miscellaneous Design for preventing Fires and Explosion.		
Unit V	**HAZOP Analysis**	**(03 Hours)**
Hazards identification: process hazards checklists, hazard surveys, hazard and operability studies (HAZOP), safety reviews. Risk assessment: review of probability theory, interaction between process units, revealed and unrevealed failure, and probability of coincidence, event trees and fault trees.		

List of Assignments (Any 8 Assignments from the given list)

Assignment:

- **Based on group of five students or the practical batch the problem values can be changed for the same assignments question and assessed accordingly.**
- **Each student has to complete any EIGHT assignments (from the given list)**
- **Assignments to be submitted as Term Work:**

1. **Critical analysis on process safety:** Key importance, benefits and regulatory requirements.
2. **Hazard Identification and Risk Assessment (HIRA):** Methods and tools for identifying hazards and assessing risks.
3. **Process Safety Management (PSM)**: Overview of PSM elements, implementation, and auditing.
4. **Fire safety plan:** Develop a fire safety plan for an industrial process.
5. **Safety Instrumented Systems (SIS)**: Design, implementation, and maintenance of SIS.
6. **Relief System Design**: Sizing and design of relief systems for process safety.
7. **Fire and Explosion Protection**: Measures for preventing and mitigating fires and explosions.
8. **Human Factors in Process Safety**: Role of human error in process safety incidents and strategies for mitigation.
9. **Process Safety Incident Investigation**: Techniques for investigating and learning from process safety incidents.
10. **Personal Protective Equipment's (PPE)**: Selection of appropriate PPE for industrial tasks.
11. Case study on handling an industrial process safely.

Learning Resources

Text Books:

1. Mihir Kumar Purkait, Piyal Mondal, Murchana Changmai, Vikranth Volli, Chi-Min Shu, "Hazards and Safety in Process Industries: Case Studies", CRC Press, 2021.
2. Samarendra Kumar Biswas, Umesh Mathur, Swapan Kumar Hazra, "Fundamentals of Process Safety Engineering", CRC Press, 2022

Reference Books:

1. 1. Daniel A. Crowl, Joseph F. Louvar, "Chemical Process Safety: Fundamentals with Applications", 3rd Edition, Pearson, 2013.
2. CCPS (Center for Chemical Process Safety), "Guidelines for Process Safety Knowledge Management", John Wiley & Sons, 2024.

e-Resources:

1. **https://ftp.idu.ac.id/wp-content/uploads/ebook/ip/BUKU%20MANAJEMEN%20SAFETY/SAFETY%20INDUSTRY/Introduction%20to%20process%20safety%20for%20undergraduates%20and%20engineers%20(%20PDFDrive%20).pdf**
2. **https://hsseworld.com/e-books-fundamentals-of-process-safety-engineering/**
3. **https://www.sciencedirect.com/bookseries/methods-in-chemical-process-safety**

MOOC/NPTEL/YouTube Links:

1. **https://elearn.nptel.ac.in/shop/nptel/chemical-process-safety/?v=c86ee0d9d7ed**
2. **https://archive.nptel.ac.in/courses/103/107/103107156/**

Second Year Engineering
(2024 Pattern)

Chemical Engineering

(With effect from Academic Year 2025-26)

SEMESTER - II

Savitribai Phule Pune University Second Year of Chemical Engineering (2024 Pattern) Course Code: PCC-206-CEE Course Name: Heat 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 and Fluid Mechanics.

Course Objectives:

The objective of the course is:

1. To learn the fundamental concepts of heat transfer operations in the chemical process industries.
2. To use heat transfer principles to understand the heat transport by conduction, convection and radiation.
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: Develop the equation for conduction process for any geometry and able to calculate the rate of heat transfer.

CO2: Solve the heat transfer rate in convection for various geometric surfaces including phase change processes.

CO3: Demonstrate basic principles, mechanism and calculations of radiation heat transfer.

CO4: Design heat exchange equipment based on the need that fits to application.

CO5: Identify, formulate and solve engineering problems involving concept of conservation of energy in processes like evaporation.

Course Contents

Unit I	Conduction	(07 Hours)

Introduction, Heat Transfer and Thermodynamics, Modes of heat transfer, Heat transfer fluxes and resistances, Thermal conductivity, Fourier's law of conduction; General equation for conduction. Conduction through plane, cylindrical and spherical and composite walls, Heat losses and insulation, Critical insulation thickness, introduction to heat transfer with heat sources. Unsteady State Conduction. Fins and their importance, The concept of fin efficiency and fin effectiveness.

Unit II	Convection	(08 Hours)

Heat Transfer without Phase Change: Introduction, thermal boundary layer, Natural and forced convections, film thickness, heat transfer coefficient, various resistances, Empirical equations for

convection heat transfer in laminar and turbulent flow through tubes, through annulus and over a flat plate. Analogy between momentum and Heat Transfer, Dimensional Analysis.

Heat Transfer with Phase Change: Introduction, importance of latent heat, Pool boiling and film boiling, concept of critical heat flux. Condensation: Modes and features, Derivation of Nusselt equation on condensate film, condensation on vertical and horizontal plates, condensation on inside and outside pipes for horizontal and vertical flows.

Unit III	Radiation	(07 Hours)

Radiant energy distribution, Various laws of radiation and their derivatives, Plank's law, Wein's law. The Stefan-Boltzmann law for blackbody, Kirchhoff's law, black body, grey body, emissive power Exchange of energy between two surfaces; View factors, combined heat transfer by conduction, convection and radiation, Furnace calculations.

Unit IV	Heat Exchange Equipment	(08 Hours)

Types of heat exchangers; Co-current and counter-current flows, fouling factors, choice of thermic fluids, Equivalent diameter; LMTD, correction factors, Temperature profiles in heat exchangers, pressure drop, Process design of heat exchangers including double pipe heat exchanger, multi-pass exchangers, shell and tube heat exchanger, Design of heat exchangers using NTU method, cross flow heat exchangers, Heat transfer equipment auxiliaries: Steam trap.

Unit V	Evaporation	(08 Hours)

Introduction, solution properties, foaming, degradation due to high temperature, scaling, equipment material, types of evaporators, material and energy balance for single effect systems, boiling point elevation, capacity and economy, multiple effect evaporators. design of evaporators.

Learning Resources

Text Books:

1. J. P Holman, Souvik Bhattacharyya, 10th Edition, McGraw Hill Education Private Ltd., 2020.
2. Coulson., Richardson J.E., "Chemical Engineering", Vol-I, Pergamon Press, 2004
3. Sinnott R. K., "Chemical Engineering" Vol- VI, 4th Edition, Chemical Engineering Design, Elsevier, 2008.

Reference Books:

1. D. Q. Kern, "Process Heat Transfer", Tata McGraw-Hill, 2008.
2. Binay K Dutta, "Heat Transfer-Principles and Applications" PHI Learning Private Ltd, 2011.
3. W. L. McCabe, J. C. Smith and P. Harriott, "Unit Operations of Chemical Engineering", 7th Edition, McGraw-Hill, 2017.
4. Y. A. Cengel, "Heat and Mass Transfer" 3rd Edition Tata McGraw Hill Publications, New Delhi, 2007.

e-Books:

1. **https://hyominsite.wordpress.com/wp-content/uploads/2015/03/fundamentals-of-heat-and-mass-transfer-6th-edition.pdf**
2. **https://www.amirajcollege.in/wp-content/uploads/2020/10/3151909-heat-transfer-a-practical-approach-by-y-a-cengel.pdf**
3. **https://ahtt.mit.edu/wp-content/uploads/2020/08/AHTTv510.pdf**
4. **http://www.freeengineeringbooks.com/Chemical/Heat-Transfer-Operations.php**

MOOC/NPTEL/YouTube Links:

1. **https://archive.nptel.ac.in/courses/103/105/103105140/**
2. **https://archive.nptel.ac.in/courses/103/103/103103032/**
3. **https://archive.nptel.ac.in/courses/112/105/112105271/**

Savitribai Phule Pune University
Second Year of Chemical Engineering (2024 Pattern)
Course Code: PCC-207-CEE Course Name: Materials and Design

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

Prerequisite Courses, if any: Materials, properties of materials, Engineering Mechanics

Course Objectives:

The objective of the course is to impart the basic knowledge of materials and machine design for designing chemical process equipment, auxiliary equipment and their accessories.

Course Outcomes:

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

CO1: Understand the scope of Engineering materials, their properties, selection, and importance of corrosion

CO2: Understand Nanomaterials, synthesis methods and applications.

CO3: Analyze stresses and strains in machine elements and structures subjected to various loads

CO4: Analyze and design power transmission shafts carrying various elements like keys and couplings

CO5: Design thin and thick-walled pressure vessels for variety of unit operations

Course Contents

Unit I	Engineering Materials and Corrosion	(08 Hours)

Scope of engineering materials, Classification of Engineering Materials, Physical and Mechanical properties of Metals, Selection of Materials for process equipment.

Corrosion: Definition, Types of corrosion- Direct corrosion, Electro-chemical corrosion, Galvanic corrosion, High temperature corrosion, Factors affecting corrosion rate, Methods for control and prevention of corrosion. Numerical on corrosion rate.

Unit II	Nanomaterials	(07 Hours)

Classification, synthesis, characterization and application of Nanomaterials – Fullerenes, Bucky balls, carbon Nano tubes, fullerenes. Nano particles – silver Nano-particles. Applications of Nano materials in Chemical Industry.

Unit III	Basic Considerations in Design	(07 Hours)

Concept of Stress, Strain and Modulus of Elasticity, Factor of Safety, Stress Concentration, Lateral strain and Poisson's Ratio, Stresses due to static and dynamic loads. Thermal stresses, Impact stresses, distinction between process design and process equipment design (mechanical design), design codes.

Unit IV	Design of Shafts, Keys and Couplings	(08 Hours)

Shafts: Types of shafts, Design of shafts under steady load, suddenly applied load and fluctuating loads, shafts subjected to combined loads, equivalent bending and twisting moments.

Keys: Types of keys, stresses developed in flat keys, shear and crushing design procedure.

Couplings: Types of couplings, Design of rigid flange coupling

Unit V	Design of Pressure Vessels	(08 Hours)

Thin walled pressure vessels: Introduction to pressure vessels, design stress, design criteria, design of shell (spherical and cylindrical), design of different types of heads and closures

Thick walled pressure vessels: Stresses in thick cylinder, types of constructions, design of high pressure vessels

Learning Resources

Text Books:

1. D.Z. Jestrazebaski, "Properties of Engineering Materials, 3rd Edition, Toppers. Co. Ltd., 1987
2. J. L. Lee and Evans, "Selecting Engineering Materials for Chemical and Process Plants", Business Works 1978.
3. R. S. Khurmi and J. K. Gupta, "A Textbook of Machine Design", 25th Edition, S. Chand, 2020.
4. V. V. Mahajani, S. B. Umarji, 2014, Joshi's Process Equipment Design, Trinity Press.
5. B. C. Bhattacharya, 2015, Introduction to Chemical Equipment Design, C.B.S. Publishers.
6. J. M. Coulson, J. F. Richardson, R. K. Sinott, 2005, Chemical Engineering Design Vol. 6, Pergamon Press

Reference Books:

1. B. S. Mitchell, "An Introduction to Materials Engineering and Science for Chemical and Materials Engineers", John Wiley & Sons, 2004.
2. R. L. Norton, "Machine Design, London", UK, Prentice Hall, 2010.
3. D. W. Green, "Perry's Chemical Engineers Handbook", McGraw Hill, 2008.

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**
4. **https://sedyono.wordpress.com/wp-content/uploads/2015/10/ch-02.pdf**
5. **https://www.me.iitb.ac.in/~ramesh/courses/ME423/materials.pdf**

MOOC/NPTEL/YouTube Links:

1. **https://archive.nptel.ac.in/courses/112/105/112105125/**
2. **https://archive.nptel.ac.in/courses/112/106/112106293/**
3. **https://archive.nptel.ac.in/courses/113/102/113102080/**

Savitribai Phule Pune University, Pune

Second Year of Chemical Engineering (2024 Pattern)

Course Code: PCC-208 -CEE Course Name: Mechanical Operations

Teaching Scheme	Credit	Examination Scheme
Theory: 02 Hours/Week	**02**	**CCE: 30 Marks** **End-Semester: 70 Marks**

Prerequisite Courses: Engineering Mathematics, Applied Science, Basic in Environmental Science / Engineering, Fluid Mechanics, Engineering Materials and Process Calculations.

Course Objectives:

The objective of the course is:

1. To study properties and characteristics of solids, separation and size reduction of solids.
2. To understand fluid- solid separations using classification, gravity settling & sedimentation, fluidization with its application of pneumatic conveying, and beneficiation methods.
3. To study mixing of powders, viscous materials & pastes, agitation of fluids and filtration.

Course Outcomes:

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

CO1: Classify equipment for screening and size reduction according to properties of solids.

CO2: Make use of thickeners, clarifiers and centrifuges for solid- liquid separations.

CO3: Apply fluidization technique and beneficiation methods in process industries**.**

CO4: Identify an appropriate type of impeller for mixing of a particular mixture and to estimate power required for agitation of fluids.

CO5: Understand basic principles for design of filtration equipment.

Course Contents

Unit I	Screening and Size Reduction of Solids	(06 Hours)

Properties and characteristics of solids, performance of screening equipment / testing sieves, U.S. Standard sieve series, Tyler Standard screen series, Sieve Shaker, types of screen analysis.

Necessity of size reduction, crushing efficiency, energy requirement calculations by using crushing laws, classification of size reduction equipment, study of Crushers, Grinders and Ultrafine Grinders. Dry versus wet grinding. Open circuit grinding and closed circuit grinding.

Unit II	Settling and Sedimentation	(07 Hours)

Theory of particle movement through a fluid. Free settling & Hindered settling. Stokes' law and Newton's law of settling. Differential settling and separation of solids in Classification, Sink-and-float methods, Differential settling methods. Basic principle of Sedimentation and its applications in water purification & wastewater treatment. Batch Sedimentation Test, Kynch theory of sedimentation, determination of thickener area and depth of thickener. Study of Thickeners, Clarifiers, and Equipment for Classification: Simple gravity settling classifier. Centrifuge equipment for Sedimentation: Tubular centrifuge and Disk bowl centrifuge.

Unit III	Fluidization and Beneficiation Methods	(06 Hours)

Types of fluidization, fluidized bed systems, determination of minimum fluidization velocity, flow through packed bed, applications of fluidized bed, Ergun equation, Kozeny-Carman equation. Study of Pneumatic conveying systems. Study of Flotation Cell, Magnetic Separator, Cyclone Separator, Hydro-cyclone, Electrostatic Precipitator, Scrubbers, and Applications of Bag filters in Air pollution control, and Hydraulic jigs in coal and ore industries.

Unit IV	Mixing and Agitation	(05 Hours)

Types of Impellers, flow patterns in un-baffled and baffled tanks, draft tube, mechanically agitated vessel, power required for agitation of fluids. Agitator scale-up. Mixing of powders, viscous material

, and pastes. Performance of mixers- determination of mixing index.

Unit V	Filtration	(06 Hours)

Basic theory of filtration, filtration equations for constant- pressure filtration, constant rate filtration, and continuous filtration. Types of filtration equipment, classification of filters. Theory and applications of Bed filters, Plate-and-frame-filter presses, Leaf filters, Continuous rotary filters. Filter media and filter aids. Equations for washing of filter cakes. Equipment for Centrifugal filtration: Perforated rotating basket filter.

Learning Resources

Text Books:

1. W. L. McCabe, J. C. Smith and P. Harriott, "Unit Operations of Chemical Engineering", 7th Edition, McGraw-Hill, 2017.
2. C. M. Narayanan C. M. and B. C. Bhattacharya, "Mechanical Operations for Chemical Engineers-Incorporating Computer Aided Analysis", Khanna Publishers, New Delhi, 1990.
3. P. Chattopadhyay, "Unit Operations of Chemical Engineering" Vol. I, Khanna Publishers, New Delhi.

Reference Books:

1. Christie John Geankoplis "Transport Processes and Separation Process Principles (Includes Unit Operations), 4th Edition, Eastern Economy edition published by PHI Learning Pvt. Ltd., New Delhi, 2013.
2. Coulson J. M. and Richardson J. F. "Chemical Engineering" Vol. 2, 4th Edition, Pergamon Press, 1991.

e-Books:

1. **https://api.pageplace.de/preview/DT0400.9780080473796_A24385505/preview-9780080473796_A24385505.pdf**
2. **https://www.bietdvg.edu/media/department/BT/data/learning-materials/Unit_Operation_1.pdf**
3. **https://archive.org/details/principlesofunit00fous**

MOOC/NPTEL/YouTube Links:

1. **https://archive.nptel.ac.in/courses/103/103/103103155/**
2. **https://archive.nptel.ac.in/courses/103/107/103107123/**

Savitribai Phule Pune University Second Year of Chemical Engineering (2024 Pattern) Course Code: PCC-209-CEE Course Name: Heat Transfer-Lab		
Teaching Scheme	**Credit**	**Examination Scheme**
Practical: 02 Hours/Week	**01**	**Term Work: 25 Marks** **Practical: 25 Marks**

Prerequisite Courses, if any: Fundamental knowledge of Mathematics and Fluid Mechanics.

Course Objectives:

The objective of the course is:

1. To understand fundamental concepts of heat transfer operations through experimentation.
2. To use heat transfer principles to understand the heat transport by conduction, convection and radiation.
3. To analyze of heat transfer in plate type heat exchanger.
4. To develop perception of heat transfer applications in industrial processes.

Course Outcomes:

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

CO1: Develop the equation for conduction process for any geometry and able to calculate the rate of heat transfer.

CO2: Solve the heat transfer rate in convection for various geometric surfaces including phase change processes.

CO3: Demonstrate basic principles, mechanism and calculations of radiation heat transfer.

CO4: Design and analyze different types of heat exchange equipment based on the need that fits to application.

CO5: Design and analyze performance of single effect and multiple effect evaporator.

List of Laboratory Experiments (Any 8 experiments from the given list)
1) Heat conduction- Determination of thermal conductivity
2) Convection (Natural/Forced)-Calculation of heat transfer coefficient
3) Thermal radiation-determination of emissivity
4) Construction of pool boiling curve
5) Determination of heat transfer coefficient of Double pipe heat exchanger
6) Determination of heat transfer coefficient of Shell and tube heat exchanger
7) Material balance and energy balance of Single effect evaporator
8) Design of shell and tube heat exchanger/ Calculations using HTRI software

9) Design of multiple effect evaporators using software (Excel, Chemcad, Python, UNISIM, ASPEN Etc.)

10) Study of Finned tube heat exchanger

11) Heat transfer analysis of Plate Heat exchanger

12) Heat transfer in agitated vessels

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

• All the experiments (Any Eight) mentioned in the syllabus are compulsory.

• Use of open source software and recent version is to been 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. J. P Holman, Souvik Bhattacharyya, 10th Edition, McGraw Hill Education Private Ltd., 2020.
2. Coulson., Richardson J.E., "Chemical Engineering", Vol-I, Pergamon Press, 2004
3. Sinnott R. K., "Chemical Engineering" Vol- VI, 4th Edition, Chemical Engineering Design, Elsevier, 2008.

e-Recourse:

1. **https://aero04-iitb.vlabs.ac.in/exp3/index.html**
2. **https://ht-iitb.vlabs.ac.in/**

Savitribai Phule Pune University, Pune

Second Year of Chemical Engineering (2024 Pattern)

Course Code: PCC-210-CEE Course Name: Mechanical Operations-Lab

Teaching Scheme	Credit	Examination Scheme
Practical: 02 Hours/Week	**01**	**Oral: 25 Marks**

Prerequisite Courses: Engineering Mathematics, Applied Science, Basic in Environmental Science / Engineering, Fluid Mechanics, Engineering Materials and Process Calculations.

Course Objectives:

The objective of the course is:

1. To study properties and characteristics of solids, separation and size reduction of solids through experimentation.
2. To understand fluid- solid separations using classification, gravity settling & sedimentation, fluidization with its application of pneumatic conveying, and beneficiation methods.
3. To study mixing of powders, viscous materials & pastes, agitation of fluids and filtration.

Course Outcomes:

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

CO1: Determine energy consumption and crushing law constants for a crushing equipment

CO2: Measure and evaluate efficiency of a separator.

CO3: Understand fluidization principles and apply it in chemical and allied processes.

CO4: Develop perception of mixing and determine mixing index.

CO5: Determine important criteria of filtration through systematic experimentation.

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

1) To determine overall effectiveness of a given set of standard screens by using a Sieve Shaker.
2) To determine energy consumption and crushing law constants for size reduction of lumps of solids in a Blake or Dodge Jaw Crusher.
3) To determine critical speed of a Ball Mill and average particle size of the product obtained.
4) To determine area of a batch thickener by conducting batch settling tests in a laboratory.
5) To determine minimum velocity for fluidization through a packed bed and to verify Ergun equation.
6) To determine efficiency of a Magnetic Separator for separation of a given mixture.
7) To determine collection efficiency of a Cyclone Separator based on different parameters for separation of a given mixture.

8) To determine minimum conveying velocity of a given pneumatic conveyor at different solids loading ratio for dilute- phase systems.

9) To determine mixing index or power requirement for agitation of a given mixture in a mechanically agitated vessel for comparison of different types of impellers.

10) To determine mixing index of a paste in a Sigma Mixer.

11) To determine filter medium resistance and specific cake resistance for constant pressure filtration or constant rate filtration by using a Plate-and-Frame-Filter Press.

12) To determine filter medium resistance and specific cake resistance for constant pressure filtration or constant rate filtration by using a Vacuum Leaf Filter

OR

To determine rate of filtration at constant pressure and constant rate period by using a Rotary Vacuum Drum Filter.

13) To determine rate of filtration at different rpm of a perforated basket Centrifuge.

14) A demonstration experiment on a Dorr Classifier.

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 student's Lab Journal should contain following related to every experiment –

1. Title of the experiment
2. Aim or Objective
3. Equipment with their detailed specifications.
4. Brief theory related to the experiment.
5. Diagram of the equipment or experimental set-up.
6. Observation table
7. Sample calculations for one/two reading.
8. Result tables
9. Graph and Conclusions.

Guidelines for Laboratory Conduction

• All the experiments (Any Eight) mentioned in the syllabus are compulsory.

• 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

Text Books:

1. W. L. McCabe, J. C. Smith and P. Harriott, "Unit Operations of Chemical Engineering", 7th Edition, McGraw-Hill, 2017.
2. C. M. Narayanan C. M. and B. C. Bhattacharya, "Mechanical Operations for Chemical Engineers-Incorporating Computer Aided Analysis", Khanna Publishers, New Delhi, 1990.
3. P. Chattopadhyay, "Unit Operations of Chemical Engineering" Vol. I, Khanna Publishers, New Delhi.
4. Coulson J. M. and Richardson J. F. "Chemical Engineering" Vol. 2, 4th Edition, Pergamon Press, 1991.

e-Resources:

1. **https://www.vlab.co.in/broad-area-chemical-engineering**
2. **https://fm-nitk.vlabs.ac.in/**

Savitribai Phule Pune University
Second Year of Chemical Engineering (2024 Pattern)
Course Code: MDM-231-CEE Course Name: Introduction to Data Science

Teaching Scheme	Credits	Examination Scheme
Theory: 02 Hours/Week	**02**	**CCE: 30 Marks** **End-Semester: 70 Marks**

Prerequisite Courses, if any: Engineering Mathematics

Course Objectives:

The objective of the course is to impart the basic knowledge of data science to be applied to chemical process industries.

Course Outcomes:

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

CO1: Develop basic idea on types of data and processing

CO2: Learn to analyze the data and obtain relation among them

CO3: Develop proficiency of various regression strategies

CO4: Learn data driven property prediction and soft sensor development

CO5: Apply data science to chemical engineering and allied fields

Course Contents

Unit I	Introduction to Data Science	(06 Hours)

Types of data: structured data, unstructured data, other data types, the data science process, Exploration and visualization of data, Linear algebra for data science, Basics of python for data science and machine learning.

Unit II	Statistics for Data Science	(06 Hours)

Data distributions, Measures of central tendency and variability, Probability an distributions, Hypothesis testing, Confidence intervals, Correlation analysis, Pre-processing of data: Scaling, Normalizing, Dimensionality Reduction, Time-series analysis.

Unit III	Regression and Classification	(06 Hours)

Simple Linear Regression, Multiple Linear Regression, Polynomial Regression, Logistic Regression, k-Nearest Neighbors, Naive Bayes, Decision Trees, Principal Component Analysis and Linear Discriminant Analysis for data reduction, Model assessment measures: MSE, R^2, Confusion Matrix, Precision, Recall etc.

Unit IV	Data Science Applications for Property Modeling	(06 Hours)

Cheminformatics, Data-Driven Property Prediction, Inferential Property Estimation (Soft Sensors), Applications in material science, Big data analysis.

Unit V	Data Science Applications for Dynamic Process	(06 Hours)

Process Modelling/Identification, Application to reactor modelling, Process Control, Fault Detection and Diagnosis in Chemical Processes.

List of Assignments

- To apply the knowledge of data science, statistics and machine learning to solve numerical problems of chemical process industries involving datasets.
- Detailed study to be conducted and results to be provided in form of graph, table and other representation.
- Methodology followed to be discussed in details.
- Analysis of the results and its logical interpretation to be provided.

Any 5 Assignments to be submitted from the given list:

1. **Basic Data Processing:** Introduction to Python, Numpy, Concept of Data-frame in Python, Data Cleansing, Data Normalization in Python or Excel.
2. **Data Visualization:** Visualizing Data in Excel or Python using Scatter Plots, Bar Charts etc.
3. **Regression Analysis:** Linear Regression Analysis of Chemical dataset using Excel, Python or any numerical processing software.
4. **Trend Analysis:** Collect some relevant data related to chemical engineering, provide the source and reference, identify the input and output variables, determine cause and effect relationship using any computer software.
5. **Classification:** Classification of Chemical dataset using any Statistical or ML-based method using Excel, Python or any numerical processing software
6. **Time-Series Analysis:** Determining statistical measures such as trend, seasonality, and residuals (or noise) in a time-series dataset using Excel, Python or any numerical processing software
7. **Chemical Property Prediction:** Regression of Chemical dataset for Property Prediction using any Statistical or ML-based method using Excel, Python or any numerical processing software.

Learning Resources

Text Books:

1. Data Science for Engineers, Rengaswamy, R., & Suresh, R., CRC Press, 2022.
2. Data Science from Scratch: First Principles with Python, Joel Grus, O'Reilly Media, 2015

3. Artificial Intelligence: A Modern Approach, S. J. Russel and P. Norvig, Pearson Education Ltd., 2022
4. Elements of artificial neural networks with selected applications in chemical engineering, and chemical & biological sciences, Tambe, S. S., Deshpande, P. B., Kulkarni, B. D., & Ramani, S, Simulation & Advanced Controls, Incorporated, 1996.

Reference Books:

1. Advanced Data Analysis and Modeling in Chemical Engineering, D. R. Dhooge, D. Constales, G. S. Yablonsky, G. B. Marin, Elsevier Science Ltd, 2016.
2. AI in Chemical Engineering: Unlocking the Power Within Data, José A. Romagnoli (Author), Luis Briceño-Mena (Author), Vidhyadhar Manee, CRC Press, 2024

e-Books:

1. **https://www.aiche.org/resources/publications/cep/2017/february/data-science-chemical-engineers**
2. **https://pubs.acs.org/doi/10.1021/acs.iecr.2c01788**
3. **https://www.thechemicalengineer.com/features/data-science-and-digitalisation-for-chemical-engineers/**
4. **https://www.cheme.washington.edu/undergraduate_students/datascience**
5. **https://chem-eng.utoronto.ca/ai-ml-data-analytics-in-chemical-engineering-applied-chemistry/**
6. **https://aiche.onlinelibrary.wiley.com/doi/10.1002/aic.15192**

MOOC/NPTEL/YouTube Links:

1. **https://onlinecourses.nptel.ac.in/noc21_cs69/preview**
2. **https://nptel.ac.in/courses/110106072**

Savitribai Phule Pune University

Second Year of Chemical Engineering (2024 Pattern)

Course Code: VSEC-270-CEE Course Name: Chemical Engineering Skills

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

Course Objectives:

1. To develop understanding about drawing of shafts, keys, couplings etc.
2. To impart the basic concepts of chemical engineering drawing, mechanical design and process design for different process equipment
3. To learn fundamentals of stoichiometry and apply the material and energy balance concepts and precisely calculate the discharge of materials or energy required to carry out the suitable unit operation or process.
4. To develop analytical chemistry skill set on solution preparation and chemical synthesis.
5. To develop the ability of sample characterization and analysis.

Course Outcomes:

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

CO1: Analyze power transmission shafts carrying various elements like keys and couplings with geometrical features.

CO2: Design the vessels for variety of unit operations often used in chemical industry.

CO3: Perform material balance with and without chemical reaction and energy balances using the aid of computer.

CO4: Develop hands on experience on various solution preparations and chemical synthesis.

CO5: Develop the ability of diversified sample characterization and analysis often used in chemical industry.

Course Contents

List of Assignments (Minimum 11 Assignments from Section I and II together)

Section I: Development of Chemical Engineering Skillset

IMPORTANT NOTE:

Minimum 6 experiments are necessary to be performed **by each student.**

PART (A)

Guidelines:

Calculation and drawings are expected. In certain cases, students can only draw the components wherever applicable. For each drawing sheet the problem statement should be formulated/ given based on the drawing sheet portion/ syllabus mentioned below

***** Any <u>THREE drawing sheets</u> out of SIX mentioned below.**

1. **Design and drawing of shafts**
   Shafts: Types of shafts, Design of shafts under steady load, suddenly applied load and fluctuating loads, shafts subjected to combined loads, equivalent bending and twisting moments, power calculations of motor.

2. **Keys and couplings**
   Keys: Types of keys, stresses developed in flat keys, shear and crushing design procedure.
   Couplings: Types of couplings, Design of rigid flange coupling

3. **Design of joints**
   Joints: Design of riveted joints, strength and efficiency of a riveted joint, Types of welded joints, Design of welded joints, strength of transverse fillet welded joints, strength of parallel fillet welded joints, strength of butt joints

4. **Design of Drives**
   Types of belts and belt drives, Velocity ratio, slip and creep of the belt, length of belt, ratio of driving tension, condition for transmission of maximum power

5. **Design of thin-walled pressure vessel**
   Codes and standards for pressure vessels (IS: 2825:1969), design stress, design criteria, design of shell (spherical and cylindrical), design of different types of heads and closures, design of flanges and nozzles, compensation for openings and branches.
   Design of pressure vessels subjected to external pressure: design of shell, heads, stiffening rings as per IS: 2825: 1969

6. **Design of thick-walled pressure vessels (High pressure vessel)**
   Materials of construction, stresses in thick cylinder, prestressing of thick walled vessels, monoblock, multilayer, autofrettage, shrink fitted shell, ribbon and wire wound vessel, analysis and design of high pressure vessels including shell and head along with the stress distribution

PART (B)

***** Any <u>THREE process calculations</u> out of SEVEN mentioned below.**

Important Note: The additional advantage can be secured by students as a mini- project combining Serial numbers 1, 3 and 5 OR 1, 4 and 6 mentioned below.
Note that a min-project is an added advantage and is a part of individual student's interest.

1. Drawing of flow diagram in AutoCAD/ HYCAD. Note that student should be able to draw the flow diagram/s in the drawing software.

2. Mass Balance Calculations without Chemical Reaction.
   The flow sheets such as Paper production from pulp, Porland Cement or mixing without reactions can be given. The problem statement is necessary. The flow diagram is necessary to be drawn wherever applicable.

3. Mass Balance Calculations with Chemical Reaction - 1
   The flow sheets such as production of liquid Bromine, Calcium Carbide, formaldehyde or any small flow diagram or block wise material balance is necessary. Note that this should cover the fundamental idea of Material Balance with reaction for small flow diagrams or blocks. The problem statement is necessary. The flow diagram is necessary to be drawn. All the streams should be named/ tagged and stream wise calculations are expected.

4. Mass Balance Calculations with Chemical Reaction - 2
   The flow sheets such as production of Methanol, Acetone, Isopropanol, Ethylene dichloride, Vinyl Chloride or any other flow sheet can be given. The problem statement is necessary. The mass balance idea is applicable block wise or unit wise here. The flow diagram is necessary to be drawn. All the streams should be named/ tagged and stream wise calculations are expected.

5. Energy Balance Calculations with Chemical Reaction - 1
   The flow sheets such as production of liquid Bromine, Calcium Carbide, formaldehyde or any small flow diagram or block wise energy balance is necessary. Note that this should cover idea of Energy Balance with reaction for small flow diagrams or blocks. The problem statement is necessary. The flow diagram is necessary to be drawn. All the streams should be named/ tagged and stream wise calculations are expected.

6. Energy Balance Calculations with Chemical Reaction - 2
   The flow sheets such as production of Methanol, Acetone, Isopropanol, Ethylene dichloride, Vinyl Chloride or any other flow sheet can be given. The problem statement is necessary. The energy balance idea is applicable block wise or unit wise here. The flow diagram is necessary to be drawn. All the streams should be named/ tagged and stream wise calculations are expected.

7. Recycle and purge operations

A small block diagram is necessary to be drawn and problem statement should be given.

Calculations such as recycle ratio/ purge ratio, effect of recycle on yield are expected.

Section II: Development of Applied Chemistry Skillset

Any 5 experiments from the given list:

1) Determination of purity of sodium Carbonate by titration method.

2) Estimation of glucose/acetone in solution.

3) Conversion of benzoic acid into its anilide derivative and its crystallization

4) Purification of organic compounds by crystallization and sublimation and take TLC (Two compounds)

5) Analysis of sample on HPLC/FTIR/GC

6) To estimate sodium ion concentration in solution by flame photometer

7) Bromination of acetamide using ferric ammonium nitrate and KBr in aqueous medium

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

• Use of open source software and recent version is to been 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 for Drawing Sheets

1. R. S. Khurmi, J. K. Gupta, "A Textbook of Machine Design", Eurasia Publishing House, 2005,
2. V. V. Mahajani, S. B. Umarji, "Joshi's Process Equipment Design", Trinity Press, 2014.
3. L. E. Brownell, E. Young, "Process Equipment Design", John Wiley, New York, 1963.
4. B. C. Bhattacharya, "Introduction to Chemical Equipment Design", C.B.S. Publishers, 2015.
5. J. M. Coulson, J. F. Richardson, R. K. Sinott, "Chemical Engineering Design", Vol. 6, Pergamon Press, 2005.

Reference Books for Process Calculations

1. B.I. Bhatt and S. M. Vora, "Stoichiometry", 2nd Edition, Tata McGraw Hill, New Delhi, 2004
2. O. A. Hougen, R. M. Watson and R. A. Ragatz, "Chemical Process Principles Part I", 2nd Edition, CBS Publications, 1976.
3. K. V. Narayanan and B. Lakshmikutty, "Stoichiometry and Process Calculations", 2nd Edition, Prentice Hall of India, New Delhi, 2009.
4. V. Venkatramani, N. Ananatharaman, Sheriffa Begum, "Process Calculations", 2nd Edition, Prentice Hall of India, 2011.
5. R.K. Sinnott, J.M. Coulson, and J.F. Richardson, "Coulson & Richardson's Chemical Engineering" Volume 6, Elsevier Butterworth-Heinemann
6. M. Gopala Rao, Marshall Sittig, and Charles Dryden, "Dryden's Outlines of Chemical Technology for the 21st Century", 3rd edition, Publisher: Affiliated East-West Press.

Reference Books for Applied Chemistry Practical:

1. J.D. Lee, "Inorganic Chemistry", 5th Edition, , Wiley, 2012
2. P.L. Soni, "Physical Chemistry", S. Chand Publishing, 2006
3. P.W. Atkins, "Physical Chemistry", Oxford University Press, 10th Edition, 2014
4. Instrumental Methods of Chemical Analysis, Himalaya Publishing House, 5th Edition, 2009
5. R. Chatwal and S. Anand, "Analytical Chemistry", Wiley, 7th Edition, 2003.
6. J. March, "Reaction Mechanism in Organic Chemistry", 7th Edition, Wiley, 2013.
7. H.H. Willard, L.L. Merritt, J.A. Dean and F.A. Settle, "Instrumental Methods of Analysis", CBS Publishers, 7th Edition, 1988.
8. J. Clayden, N. Greeves, and S. Warren, "Organic Chemistry", Oxford University Press, 2nd Edition, 2012

e-Resources:

1. **https://onlinecourses.nptel.ac.in/noc21_ch18/preview**
2. **https://archive.nptel.ac.in/courses/103/103/103103027/**

Savitribai Phule Pune University
Second Year of Engineering (2024 Course)
Course Code: AEC-281-CEE Course Name: Modern Indian Language (Marathi)

Teaching Scheme:	Credit	Examination Scheme:
Tutorial: 1 Hour/Week Practical:2 Hours/Week	02	Term Work: 50 Marks

Prerequisite Courses, if any: Knowledge of basic Marathi and Hindi language

Course Objectives:

अभ्यासक्रमाची उद्दिष्टे :

१. प्रगत भाषिक कौशल्यांची क्षमता विकसित करणे.
२. प्रसारमाध्यमांतील संज्ञापनातील स्वरूप आणि स्थान स्पष्ट करणे.
३. व्यक्तिमत्त्व विकास आणि भाषा यांच्यातील सहसंबंध स्पष्ट करणे.
४. लोकशाहीतील जीवनव्यवहार आणि प्रसारमाध्यमे यांचे परस्पर संबंध स्पष्ट करणे.
५. प्रसारमाध्यमांसाठी लेखनक्षमता विकसित करणे.

Course Outcomes: After successful completion of the course, learner will be able to understand and speak Marathi

Course Contents

Unit I & II **(12 Hours)**

घटक	तपशील
१	१. भाषा आणि व्यक्तिमत्त्व विकास : सहसंबंध २. लोकशाहीतील जीवनव्यवहार आणि प्रसारमाध्यमे
२	प्रसारमाध्यमांसाठी लेखन १ वृत्तपत्रासाठी बातमीलेखन आणि मुद्रितशोधन २ नभोवाणीसाठी भाषणाची संहितालेखन ३ दूरचित्रवाणीसाठी माहितीपटासाठी संहितालेखन

Unit III & IV **(12 Hours)**

१	१. भाषा, जीवन व्यवहार आणि नवमाध्यमे, समाजमाध्यमे २. नवमाध्यमे आणि समाजमाध्यमांचे प्रकार : ब्लॉग, फेसबुक, ट्विटर. ३. नवमाध्यमे आणि समाजमाध्यमांविषयक साक्षरता, दक्षता, वापर आणि परिणाम
२	१. वेबसाईट आणि ब्लॉग, ट्विटरसाठी लेखन २. व्यावसायिक पत्रव्यवहार

Learning Resources

Suggested Reading:

संदर्भ ग्रंथ :

१ सायबर संस्कृती, डॉ. रमेश वरखेडे
२ उपयोजित मराठी, संपादक डॉ. केतकी मोडक, संतोष शेणई, सुजाता शेणई
३ ओळख माहिती तंत्रज्ञानाची, टिमोथी जे. ओ लिअरी
४ संगणक, अच्युत गोडबोले, मौज प्रकाशन, मुंबई.
५ इंटरनेट, डॉ. प्रबोध चोबे, मनोरमा प्रकाशन, मुंबई.
६ व्यावहारिक मराठी, डॉ. ल. रा. नसिराबादकर, फडके प्रकाशन, कोल्हापूर.
७ आधुनिक माहिती तंत्रज्ञानाच्या विश्वात, शिक्रापूरकर दीपक, मराठे उज्ज्वल, उत्कर्ष प्रकाशन, पुणे.

Savitribai Phule Pune University
Second Year of Engineering (2024 Course)

Course Code: AEC-281-CEE Course Name: Modern Indian Language (Hindi)

Teaching Scheme:	Credit	Examination Scheme:
Tutorial: 1 Hour/Week **Practical: 2 Hours/Week**	**02**	**Term Work: 50 Marks**

Prerequisite Courses, if any: Knowledge of basic Marathi and Hindi language

Course Objectives:

उद्देश्य :

१. छात्रों में हिंदी भाषा श्रवण कौशल विकसित करना।
२. छात्रों में हिंदी भाषा संवाद कौशल विकसित करना।
३. छात्रों में हिंदी भाषा वाचन कौशल विकसित करना।
४. छात्रों में हिंदी भाषा लेखन कौशल विकसित करना।
५. हिंदी भाषा–विधि तथा भाषा–व्यवहार से अवगत करना।

Course Outcomes: After successful completion of the course, learner will be able to understand and speak Hindi

Course Contents

Unit I & II **(12 Hours)**

इकाई	पाठ्यविषय
इकाई– I	**वर्ण विचार :** १) हिंदी वर्णमाला – परिचय २) लिपि – परिचय ३) वर्णों का उच्चारण और वर्गीकरण ४) स्वराघात ५) संधि : स्वर संधि, व्यंजन संधि, विसर्ग संधि।

Unit III & IV **(12 Hours)**

इकाई– II	**भाषा कौशल शिक्षण : लघुकथाओं द्वारा भाषा कौशल शिक्षण (श्रवण, संवाद, वाचन, लेखन)** १) शिक्षा – ज्योति जैन २) पानी के पेड़ – ज्योति जैन ३) पशुभाषा – ज्योति जैन ४) अपशगुन – ज्योति जैन

Learning Resources

Suggested Reading:

संदर्भ ग्रंथ :

१. हिंदी भाषा शिक्षण — संपा. हिंदी अध्ययन मंडल, सावित्रीबाई फुले पुणे विश्वविद्यालय, पुणे, राजकमल प्रकाशन, नई दिल्ली।

२. हिंदी व्याकरण — पं. कामताप्रसाद गुरु, प्रकाशन संस्थान, नई दिल्ली।

३. प्रयोजनमूलक हिंदी — डॉ. माधव सोनटक्के, लोकभारती प्रकाशन, नई दिल्ली।

Savitribai Phule Pune University, Pune
Second Year of Chemical Engineering (2024 Pattern)
Course Code: EEM-241-CEE Course Name: Chemical Industry Management

Teaching Scheme	Credit	Examination Scheme
Tutorial: 01 Hour/Week **Practical: 02 Hours/Week**	**02**	**Term Work: 25 Marks**

Prerequisite Courses: Chemical Engineering Principles, Basic Mathematics

Course Objectives:

The objective of the course is:

1. To study management principles and personal management.
2. To understand purchases and store management.
3. To develop perception of marketing management
4. To have some idea on export and import management
5. To study and understand management laws.

Course Outcomes:

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

CO1: Understand management principles and idea of personal management.

CO2: Make use of management principles in purchase and effective management of stores.

CO3: Apply principles of management in marketing to enhance effectiveness.

CO4: Utilize principles of management in export and import processes.

CO5: Develop perception on management laws and their implementation.

Course Contents

Unit I	Management Science and Personal Management	(03 Hours)

A. Management, its growth, concepts of administration and management of organization. Definition of management, functions, authority and responsibility.

B. Personality: Physical appearance, body language, voice, communication style, content of communication, enriched communication through Sensory Specific Language. Dress codes, Guidelines for appropriate business attire.

Manpower planning, sources of recruitment, selection and training of staff, job evaluation, merit rating, performance appraisal, wage administration and system of wage payment, incentive, motivations, industrial fatigue, trade unions – industrial relations. Introduction to personal selling & salesmanship: Defining personal selling and salesmanship, Selling as a profession, Objectives and importance of personal selling, Essentials of personal selling,

Unit II	Purchase and Store management	(03 Hours)
Concepts of quotation, tenders and comparative statement, inspection and quality control, inventory, carrying cost and fixed cost of inventory, examples of cost of Inventory, stores management, functions of storekeeper, methods of inventory : LIFO, FIFO. Credit analysis and appraisal principles of credit management: Principles of lending –evaluation of borrower – sanction limit-principles of good lending.		
Unit III	**Marketing Management**	**(03 Hours)**
Concepts of selling, marketing, definition of marketing, market research and of pricing, penetration, pricing, skimming pricing, distribution of product, advertising and promotion. Introduction to product management: Product management as a basis of marketing organization structure. Role of product manager, skills required for product management. Product management in consumer product industry vs industrial product industry. Overview of product level marketing plans.		
Unit IV	**Export and Import Management**	**(03 Hours)**
Concepts of international trade, duties, antidumping duty, cost involved in exporting a product, pricing of export product. Government aids for export promotion, export houses, export promotion counsel, MODVAT, patent and patent rights. Quality Management: TQM, quality circles, ISO systems. Inflation: Meaning, types of inflation, causes, effects, control of inflation, value of money, index numbers, construction, utility, limitations, business cycles, phases of business cycles.		
Unit V	**Management Laws**	**(03 Hours)**
Concepts of contract act, offer, and acceptance, types of contracts, void contract, concept of guarantee and warranty. Introduction of MRTP and FERA. Work study: Work measurement, motion and time study flow process chart, flow diagram, silo chart, string chart, therbligs. Patent law: Patent cooperation treaty, patent act 1970, procedure for filing patent applications, patent granting procedures, revocation.		

List of Assignments (Any 8 Assignments from the given list)

1) Study of marketing strategy analysis
2) Preparation of comparative statement for Inventory
3) Study of ISO systems
4) Study of total quality management
5) Study of international trade: Export and Import
6) Study of incentive plan management
7) Study of organization structure and its types
8) Study of wage administration system
9) Study of management laws

10) Study of product, marketing, and selling management through industrial visit

11) Case study on preparation of patent draft

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 student's Lab Journal should contain following related to every experiment –

1. Title of the experiment
2. Aim or Objective
3. Equipment with their detailed specifications.
4. Brief theory related to the experiment.
5. Diagram of the equipment or experimental set-up.
6. Observation table
7. Sample calculations for one/two reading.
8. Result tables
9. Graph and Conclusions.

Guidelines for Laboratory Conduction

• All the Assignments **(Any Eight)** mentioned in the syllabus are compulsory.

• 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

Text Books:

1. A. W. Stonier and D. C. Hague, "A Text Book of Economic Theory", Longman.
2. George Leland Bach, "Economics -Analysis, Decision Making and policy", Prentice Hall Inc.
3. M. L. Seth, "Principles of Economics", Lakshmi Narayan Agarwal, Agra.
4. A. N. Agarwal, "Indian Economy", Vikas Publishing House Pvt. Ltd., New Delhi.

5. R. Datta and K. P. M. Sundharam, “Indian Economy” S. Chand & Co. Ltd., New Delhi.

Reference Books:

1. Bonham F, “Economics”, Sir Isaac Pitman and Sons Ltd., London.
2. Peter F. Drucker, “The Practice of Management”, Allied publishers pvt. ltd., Bombay.
3. Barat, Nikhil, “Production management & Control”, Academic Publishers, Calcutta.
4. Garrett, Leonard J. & Silver, Milton, “Production Management Analysis”, Harcourt Brace Jovanovich, Inc. New York.

e-Resoucess:

1. **https://link.springer.com/book/10.1007/978-3-319-28253-4**
2. **https://company.tom-tailor.com/fileadmin/user_upload/tt_chemical_management_handbook_v2.0_aug_2020.pdf**
3. **https://sustainabledevelopment.un.org/content/documents/SAICM_publication_ENG.pdf**

Savitribai Phule Pune University, Pune
Second Year of Chemical Engineering (2024 Pattern)
Course Code: VEC-251-CEE Course Name: Environmental Studies

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

Prerequisite Courses: Basic Science, Chemical Engineering Principles, Applied Chemistry

Course Objectives:

1. To understand the importance of environmental conservation and sustainability.
2. To learn about ecological principles, including ecosystems, biodiversity, and natural resources.
3. To understand various environmental issues, such as climate change, pollution, and conservation.
4. To learn about sustainable development and its importance in environmental conservation.
5. To develop collaboration skills to work with others on environmental projects.

Course Outcomes:

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

CO1: Develop a sense of environmental responsibility and stewardship.

CO2: Develop an appreciation for nature and its importance in human well-being.

CO3: Perform the work studies for sustainability and environmental conservation.

CO4: Apply environmental principles to real-world problems.

CO5: Create the problem-solving and decision-making skills to address environmental challenges.

Course Contents

Unit I	Overview of Environmental Engineering	(05 Hours)

An overview of environmental engineering, pollution of air, water and soil, impact of population growth on environment, environmental impact of thermal, hydro and nuclear energy, chemical pollution, solid wastes, prevention and control of environmental pollution, water and air pollution laws and standards.

Unit II	Air-Pollution Sources and Control	(07 Hours)

Definition of air pollution, sources scales of concentration and classification of air pollutants. Effects of air pollutants on human health, plants, animals, materials, Economic effects of air pollution, sampling and measurement of air pollutants, air pollution control standards: WHO, BIS, MPCB, CPCB. Particulate pollution: cleaning methods, collection efficiency, particulate collection systems, Operating principles of settling chamber, cyclone separator, fabric filter, electrostatic precipitator. Operating principles of spray tower, centrifugal scrubber, venturi scrubber. Gaseous pollution: Principles of control by absorption, adsorption, combustion and catalytic oxidation.

Unit III	Water Pollution	(06 Hours)
Domestic and industrial wastewater, types, sources and effects of water pollutants. Waste water characteristics–DO, BOD, COD, TOC, total suspended solids, colour and odour, bacteriological quality, oxygen deficit, determination of BOD constants. Water quality standards: ICMR, WHO, MPCB and CPCB.		
Unit IV	**Wastewater Treatment**	**(06 Hours)**
Principles of primary treatment and secondary treatment, basic operating principles of activated sludge (suspended growth) process, sludge treatment and disposal, trickling filter. Advanced methods of waste water treatment: UASB, photo catalytic reactors, wet-air oxidation, and biosorption. Tertiary treatment: disinfection by chlorine, ozone and hydrogen peroxide, and UV rays.		

List of Assignments/Tutorials

Assignments/Tutorials

Guidelines:

1. **Based on group of five students or the practical batch the problem values can be changed for the same tutorial question and assessed accordingly.**
2. **Each student to solve <u>any EIGHT tutorials (as per following list) and visit ONE waste water treatment unit.</u>**
3. **Assignments to be submitted as Term Work**

1) Arrange a debate on Government Policy on a ban of plastic bags.
2) Write essay / prepare poster / develop model on Global Warming
3) With a neat diagram and explain the Hydrologic Cycle.
4) Conduct a study on major toxic pollutants and their effect on human health.
5) With help of relevant references document the effect of Air Pollution on various materials.
6) Conduct a study on effect of specific air pollutants on vegetation.
7) Explain with diagram different air pollution control methods.
8) Explain usage of cyclone separator to minimize air pollution.
9) With help of neat diagram explain operation of electrostatic precipitator.
10) Explain with diagram – wet scrubbers, thermal incinerator and spray tower.
11) Conduct a systematic investigation on water pollutants.
12) Study pH and DO (dissolved oxygen) content of waste-water.
13) Study on BOD or COD measurement of waste water

14) Explain water characteristics and inherent relation among COD, BOD and TOC.

15) Technological perspective of activated sludge treatment.

16) Study of trickling bed filter for a predefined wastewater treatment operation.

17) Science behind advanced wastewater treatment methods.

18) Study an oil-spill or similar accident and ways and operations conducted to minimize the environmental damage – Submit the report as mini project.

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 student's Lab Journal should contain following related to every experiment –

1. Title of the experiment
2. Aim or Objective
3. Equipment with their detailed specifications.
4. Brief theory related to the experiment.
5. Diagram of the equipment or experimental set-up.
6. Observation table
7. Sample calculations for one/two reading.
8. Result tables
9. Graph and Conclusions.

Guidelines for Laboratory Conduction

• All the experiments **(Any Eight)** mentioned in the syllabus are compulsory.

• 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

Text Books:

1. 1 Rao C. S. “Environmental Pollution Control Engineering”, Wiley Eastern Publications, 2018.
2. Metcalf and Eddy “Wastewater Engineering: Treatment and Reuse”, Tata McGraw Hill Publishers, 2017.
3. Mahajan S.P. “Pollution Control in Process Industry”, Tata McGraw Hill Publishers, 1987.
4. J.C. Mycock, John D. McKenna, Louis Theodore “Handbook of Air Pollution Control Engineering and Technology”, CRC Press, 2000.

Reference Books:

1. Flagan R.C. and Seinfield J.H. “Fundamentals of Air Pollution Engineering” Prentice- Hall, Inc., Prentice Hall, 1988.
2. Martin Crowford “Air Pollution Control theory” McGraw-Hill Inc.,US.
3. Arthur C. Stern, “Air Pollution”, Vol.-I and Vol.-II, 2nd Edition, Academic Press, New York,1968

e-Resoucess:

1. **https://onlinecourses.swayam2.ac.in/cec25_es01/preview**
2. **https://www.open.edu/openlearn/nature-environment/free-courses**
3. **https://onlinecourses.nptel.ac.in/noc24_hs160/preview**
4. **https://ocw.mit.edu/collections/environment/**

Task Force for Curriculum Design and Development

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