PPSU

P P SAVANI UNIVERSITY

# SCHOOL OF ENGINEERING

## M. TECH. (CHEMICAL ENGINEERING)

## SYLLABUS BOOK

## AY 2025-26

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

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

Graduates will demonstrate ability to:

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

| PO No | PROGRAMME OUTCOMES |
|---|---|
| PO 1 | Engineering Knowledge:<br>Apply the knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems. |
| PO 2 | Problem Analysis:<br>Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first-principles of mathematics, natural sciences and engineering sciences.. |
| PO 3 | Design/Development of Solutions:<br>Design solutions for complex engineering problems and design system-components or processes that meet specified needs with appropriate consideration for public health & safety, cultural, societal and environmental considerations. |
| PO 4 | Conduct Investigations of Complex Problems:<br>Use research-based knowledge and research methods including design of experiments, analysis & interpretation of data, and synthesis of information to provide valid conclusions for complex problems. |

| | |
|---|---|
| PO 5 | Engineering Tool Usage:<br>Create, select, and apply appropriate techniques, resources, and modern engineering & IT tools including prediction and modelling to engineering activities, with an understanding of their limitations. |
| PO 6 | The Engineer and The World:<br>Apply reasoning informed by contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to professional engineering practice; understand the impact of engineering solutions in societal and environmental contexts, and demonstrate knowledge of, and need for, sustainable development. |
| PO 7 | Ethics:<br>Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice. |
| PO 8 | Individual and Collaborative Team Work:<br>Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings. |
| PO 9 | Communication:<br>Communicate effectively on engineering activities with the engineering community and with society at large—such as being able to write reports, design documentation, make effective presentations and give/receive instructions. |
| PO 10 | Project Management and Finance:<br>Demonstrate knowledge and understanding of engineering and management principles and apply these to one's work, as a member or leader in a team in a multidisciplinary environment to manage projects. |
| PO 11 | Life-Long Learning:<br>Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in thse broadest context of technological change. |

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

| Credit Guidelines (General) | | | |
|---|---|---|---|
| **Component** | **Hour/Week** | **Credit** | **Total Hours/Semester** |
| Theory | 1 | 1 | 15 |
| Practical | 2 | 1 | 30 |
| Tutorial | 1 | 1 | 15 |
| Note: In specific cases; extra credits can be granted for specific/important subjects. | | | |

| CO-PO Mapping Guidelines | | |
|---|---|---|
| **Mapping Level** | **% age Mapping** | **Indicator** |
| 0 / - | 0 | No Mapping |
| 1 | 0-33 | Low Level (Slightly Mapped) |
| 2 | 33-66 | Medium Level (Moderately Mapped) |
| 3 | >66 | High Level (Strongly Mapped) |

# Syllabus Book

## M. Tech.
## (Research in Chemical Engineering)

**P P Savani University**

School of Engineering

Effective From: 2025-26

Authored by: P P Savani University

# CONTENT

# FIRST YEAR

# SCHOOL OF. ENGINEERING

| P P SAVANI UNIVERSITY | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SCHOOL OF ENGINEERING | | | | | | | | | | | | | | | | |
| TEACHING & EXAMINATION SCHEME FOR M. TECH. (RESEARCH) IN CHEMICAL ENGINEERING AY: 2025-26 | | | | | | | | | | | | | | | | |
| Sem | Course Code | Course Title | Course Category | Offered By | Teaching Scheme | | | | | Examination Scheme | | | | | | |
| | | | | | Contact Hours | | | | Credit | Theory | | Practical | | Tutorial | | Total |
| | | | | | Theory | Practical | Tutorial | Total | | CE | ESE | CE | ESE | CE | ESE | |
| 1 | SECH7010 | Research Methodology And IPR | Major/Core | CH | 3 | 0 | 2 | 5 | 5 | 40 | 60 | 0 | 0 | 40 | 60 | 200 |
| | SECH7910 | Research Project-I | RP/OJT | CH | 0 | 10 | 0 | 10 | 10 | 0 | 0 | 80 | 120 | 0 | 0 | 200 |
| | | Elective Course-I | Minor | CH | 3 | 0 | 2 | 5 | 5 | 40 | 60 | 0 | 0 | 40 | 60 | 200 |
| | | Elective Course-II | Minor | CH | 3 | 0 | 2 | 5 | 5 | 40 | 60 | 0 | 0 | 40 | 60 | 200 |
| | | | | | | | **Total** | **25** | **25** | | | | | | | **800** |
| 2 | SECE7010 | Mathematical and Numerical Technique in Research | Major/Core | CE | 3 | 0 | 2 | 5 | 5 | 40 | 60 | 0 | 0 | 40 | 60 | 200 |
| | SECH7920 | Research Project-II | RP/OJT | CH | 0 | 10 | 0 | 10 | 10 | 0 | 0 | 80 | 120 | 0 | 0 | 200 |
| | | Elective Course-III | Minor | CH | 3 | 0 | 2 | 5 | 5 | 40 | 60 | 0 | 0 | 40 | 60 | 200 |
| | | Elective Course-IV | Minor | CH | 3 | 0 | 2 | 5 | 5 | 40 | 60 | 0 | 0 | 40 | 60 | 200 |
| | | | | | | | **Total** | **25** | **25** | | | | | | | **800** |

| | | Elective Courses | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1** | SECH7510 | Physico-Chemical Processes For Wastewater Treatment | Minor | CH | 3 | 0 | 2 | 5 | 5 | 40 | 60 | 0 | 0 | 40 | 60 | 200 |
| **1** | SECH7520 | Basic Environmental Engineering And Pollution Abatement | Minor | CH | 3 | 0 | 2 | 5 | 5 | 40 | 60 | 0 | 0 | 40 | 60 | 200 |
| **1** | SECH7530 | Environmental Quality Monitoring & Analysis | Minor | CH | 3 | 0 | 2 | 5 | 5 | 40 | 60 | 0 | 0 | 40 | 60 | 200 |
| **1** | SECH7540 | Environmental Engineering | Minor | CH | 3 | 0 | 2 | 5 | 5 | 40 | 60 | 0 | 0 | 40 | 60 | 200 |
| **1** | SECH7550 | Fuel And Combustion Technology | Minor | CH | 3 | 0 | 2 | 5 | 5 | 40 | 60 | 0 | 0 | 40 | 60 | 200 |
| **1** | SECH7560 | Optimization In Chemical Engineering | Minor | CH | 3 | 0 | 2 | 5 | 5 | 40 | 60 | 0 | 0 | 40 | 60 | 200 |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **2** | SECH7570 | Chemical Process Intensification | Minor | CH | 3 | 0 | 2 | 5 | 5 | 40 | 60 | 0 | 0 | 40 | 60 | 200 |
| **2** | SECH7580 | Novel Separation Processes | Minor | CH | 3 | 0 | 2 | 5 | 5 | 40 | 60 | 0 | 0 | 40 | 60 | 200 |
| **2** | SECH7590 | Advanced Reaction Engineering | Minor | CH | 3 | 0 | 2 | 5 | 5 | 40 | 60 | 0 | 0 | 40 | 60 | 200 |
| **2** | SECH7600 | Advanced Process Control | Minor | CH | 3 | 0 | 2 | 5 | 5 | 40 | 60 | 0 | 0 | 40 | 60 | 200 |
| **2** | SECH7610 | Soft Nano Technology | Minor | CH | 3 | 0 | 2 | 5 | 5 | 40 | 60 | 0 | 0 | 40 | 60 | 200 |
| **2** | SECH7620 | Characterization Of Polymers, Elastomers And Composites | Minor | CH | 3 | 0 | 2 | 5 | 5 | 40 | 60 | 0 | 0 | 40 | 60 | 200 |

**P P Savani University**
**School of Engineering**

## Department of Chemical Engineering

Course Code: SECH7010
Course Name: Research Methodology And IPR
Prerequisite Course(s): -

**Teaching & Examination Scheme**

| Teaching Scheme (Hours/Week) | | | | Examination Scheme (Marks) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Theory | Practical | Tutorial | Credit | Theory | | Practical | | Tutorial | | Total |
| | | | | CE | ESE | CE | ESE | CE | ESE | |
| 3 | - | 2 | 5 | 40 | 60 | 0 | 0 | 40 | 60 | 200 |

CE: Continuous Evaluation, ESE: End Semester Exam

**Objective(s) of the course:**

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

**Course Content:**

| Module | Content | Hour | Weightage In % |
|---|---|---|---|
| 1 | **Introduction to Research and Research Process**<br>Meaning and objectives of research, Types of research: Fundamental, applied, exploratory, and empirical Research process and research problem formulation Criteria for good research | 5 | 10 |
| 2 | **Literature Survey and Research Ethics**<br>Sources of literature and techniques for literature review, Use of databases and citation indexing (Scopus, Web of Science, Google Scholar), Research ethics and ethical codes, Plagiarism and tools for detection (Turnitin, Grammarly, etc.) | 7 | 20 |
| 3 | **Research Design and Methodology**<br>Research design types: Descriptive, analytical, experimental, Sampling techniques and hypothesis formulation, | 5 | 10 |

| | | | |
|---|---|---|---|
| | Measurement scales and data collection methods, Case studies and surveys in research | | |
| 4 | **Data Analysis and Interpretation**<br>Statistical analysis of data (mean, median, mode, standard deviation, etc.), Hypothesis testing, confidence intervals, p-values, Correlation and regression analysis, Data visualization and interpretation using software (Excel, SPSS, R, Python) | 5 | 10 |
| 5 | **Technical Writing and Research Documentation**<br>Research paper, thesis, dissertation structure and formatting Referencing styles: IEEE, APA, MLA, Writing abstracts, technical reports, conference papers, Use of LaTeX, MS Word, and reference managers (Mendeley, Zotero) | 5 | 10 |
| 6 | **Introduction to IPR and Patent System**<br>Overview of Intellectual Property Rights, Types: Patents, copyrights, trademarks, industrial designs, trade secrets Importance of IPR in research and innovation, Indian and international patent systems (WIPO, PCT) | 8 | 20 |
| 7 | **Patent Filing and Commercialization**<br>Patent drafting, claims, and specification, Filing procedure in India and abroad, Patent search databases (Espacenet, USPTO, InPASS), Technology transfer and commercialization of IPR | 5 | 10 |
| 8 | **Case Studies and Contemporary Issues in IPR**<br>Case studies of patent infringement and IP litigation, IPR in academia and industry collaborations, Startups and IP strategies, Future trends: AI and IP, Open Innovation, Creative Commons | 5 | 10 |
| | **Total** | **45** | **100** |

**Tutorials**

| Tutorial | Content | Duration (Hours) |
|---|---|---|
| 1 | Overview of research meaning, objectives, types (fundamental, applied, exploratory, empirical); research process | 2 |
| 2 | Steps in research problem formulation; criteria for good research | 2 |
| 3 | Sources of literature; techniques for literature review using databases (Scopus, Web of Science, Google Scholar) | 2 |
| 4 | Research ethics, ethical codes, plagiarism, tools (Turnitin, Grammarly) | 2 |
| 5 | Research design types (descriptive, analytical, experimental); sampling techniques | 2 |
| 6 | Hypothesis formulation; measurement scales and data collection methods | 2 |
| 7 | Statistical measures (mean, median, mode, standard deviation); hypothesis testing | 2 |
| 8 | Correlation, regression, confidence intervals, p-values; visualization using Excel, SPSS, R, Python | 2 |
| 9 | Structure and formatting of research papers, theses; referencing styles (IEEE, APA, MLA) | 2 |
| 10 | Writing abstracts, technical reports, conference papers; LaTeX, Mendeley, Zotero | 2 |

| | | |
|---|---|---|
| 11 | Overview of IPR (patents, copyrights, trademarks, designs, trade secrets); importance in research | 2 |
| 12 | Indian and international patent systems (WIPO, PCT); patent filing basics | 2 |
| 13 | Patent drafting, claims, specifications; filing procedures; databases (Espacenet, USPTO, InPASS) | 2 |
| 14 | Technology transfer; commercialization of IPR | 2 |
| 15 | Patent infringement, IP litigation, academia-industry collaborations, startups, AI and IP, Open Innovation, Creative Commons | 2 |
| | **Total** | **30** |

**Text Book:**

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

**Reference Books:**

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

**Course Evaluation:**

**Theory:**

- Continuous Evaluation consists of two tests, each of 30 marks with a duration of 1 hour.
- Faculty Evaluation consists of 10 marks, as per the guidelines provided by the Course Coordinator.
- End Semester Examination will consist of a comprehensive 60 marks theory exam.

**Tutorials:**

- Continuous Evaluation consists of the performance in tutorials, which should be evaluated out of 10 marks for each tutorial in the next session. The average of these will be converted to 10 marks.
- Internal Viva component of 10 marks based on tutorial understanding and application.
- Tutorial-based assignment/quiz/problem-solving test of 20 marks during the End Semester Evaluation.
- Viva/Oral performance during the End Semester Evaluation carrying 10 marks.

**Course Outcome(s):**

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

| SECH7010 | Research Methodology And IPR |
|---|---|
| CO 1 | Identify appropriate research problems and design suitable methodologies for academic and industrial research. |
| CO 2 | Conduct comprehensive literature reviews using standard databases and apply ethical practices in research and writing. |

| | |
|---|---|
| CO 3 | Analyze, interpret, and validate experimental data using statistical tools and visualization techniques. |
| CO 4 | Prepare well-structured research documents and understand the publication process and citation ethics |
| CO 5 | Explain the fundamentals of Intellectual Property Rights and apply patent search, drafting, and filing concepts for protecting and commercializing research outcomes. |

**Mapping of CO with PO**

| SECH7010 | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CO 1 | 3 | 2 | | 2 | | | | | | | |
| CO 2 | 2 | 3 | | 3 | 2 | | | | | | |
| CO 3 | 2 | 3 | 3 | 3 | 3 | | | | | | |
| CO 4 | 1 | 2 | 3 | 2 | 2 | | | | | 2 | |
| CO 5 | | | | | | | | 3 | 3 | 3 | 2 |

**Mapping of CO with PSO**

| SECH7010 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|
| CO 1 | 2 | 2 | 1 |
| CO 2 | 3 | 2 | 2 |
| CO 3 | 3 | 3 | 2 |
| CO 4 | 2 | 3 | 2 |
| CO 5 | 1 | 2 | 3 |

Level of Bloom's Revised Bloom's Taxonomy in Assessment

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

| Module No | Content | RBT Level |
|---|---|---|
| 01 | Introduction to Research and Research Process | 3,5 |
| 02 | Literature Survey and Research Ethics | 1,4 |
| 03 | Research Design and Methodology | 1,3 |
| 04 | Data Analysis and Interpretation | 2,6 |
| 05 | Technical Writing and Research Documentation | 1,5 |
| 06 | Introduction to IPR and Patent System | 3,4 |
| 07 | Patent Filing and Commercialization | 2,4 |
| 08 | Case Studies and Contemporary Issues in IPR | 3,4 |

## P P Savani University
## School of Engineering
## Department of Chemical Engineering

Course Code: SECH7910
Course Name: Research Project-I
Prerequisite Course/s: -

**Teaching & Examination Scheme:**

| Teaching Scheme (Hours/Week) | | | | Examination Scheme (Marks) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Theory | Practical | Tutorial | Credit | Theory | | Practical | | Tutorial | | Total |
| | | | | CE | ESE | CE | ESE | CE | ESE | |
| - | 10 | - | 10 | - | - | 80 | 120 | - | - | 200 |

CE: Continuous Evaluation, ESE: End Semester Exam

**Objective(s) of the course:**

To help learners to

- To engage students in identifying, formulating, and solving real-world research problems.
- To encourage independent and original thinking in designing, implementing, and evaluating computational methods.
- To promote the use of research methodology, scientific writing, and effective communication of results.

**List of Practical's:**

| Sr. No. | Name of Practical | Hours |
|---|---|---|
| 1. | Orientation, topic finalization, and problem statement definition. | 10 |
| 2. | Literature review using IEEE/ACM/ScienceDirect databases. | 20 |
| 3 | Identification of research gap and formulation of research objectives. | 10 |
| 4 | Selection of methodology, tools, and technologies. | 10 |
| 5 | Initial prototype design or dataset collection/preprocessing. | 10 |
| 6 | Core development: algorithm/model/system design begins. | 10 |
| 7 | Implementation continues with performance testing. | 30 |
| 8 | Experimentation, result collection, tuning. | 20 |
| 9 | Result validation (graphs, statistical methods, comparisons). | 20 |
| 10 | Drafting research report/paper, presentation preparation | 10 |
| | **TOTAL** | **150** |

**Practical:**

- Each student should be assigned a faculty guide.
- Regular weekly review meetings are mandatory.
- Mid-term internal evaluation and final external viva should be scheduled.
- Research should ideally be aligned with current thrust areas: chemical engineering, material science etc.

**Course Outcome(s):**

After the completion of the course, the student will be able to

| SECH7910 | Research Project-I |
|---|---|
| CO1 | Identify and define a research problem with reference to current trends in Chemical Engineering. |
| CO2 | Analyze relevant literature and select appropriate tools and techniques. |
| CO3 | Develop and implement innovative solutions or models for real-world problems. |
| CO4 | Evaluate research findings and present technical documentation and publications. |
| CO 5 | Exhibit professional ethics, teamwork, and project management skills in executing a research project. |

**Mapping of CO with PO**

| SECH7910 | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CO 1 | 3 | 2 | | 2 | | | | | | | |
| CO 2 | 2 | 3 | | 3 | 2 | | | | | | |
| CO 3 | 2 | 3 | 3 | 3 | 3 | | | | | | |
| CO 4 | 1 | 2 | 3 | 2 | 2 | | | | | 2 | |
| CO 5 | | | | | | | | 3 | 3 | 3 | 2 |

**Mapping of CO with PSO**

| SECH7910 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|
| CO 1 | 2 | 2 | 1 |
| CO 2 | 3 | 2 | 2 |
| CO 3 | 3 | 3 | 2 |
| CO 4 | 2 | 3 | 2 |
| CO 5 | 1 | 2 | 3 |

**P P Savani University**
**School of Engineering**

## Department of Chemical Engineering

Course Code: SECH7510
Course Name: Physico-Chemical Processes For Wastewater Treatment
Prerequisite Course(s): -

**Teaching & Examination Scheme**

| Teaching Scheme (Hours/Week) | | | | Examination Scheme (Marks) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Theory | Practical | Tutorial | Credit | Theory | | Practical | | Tutorial | | Total |
| | | | | CE | ESE | CE | ESE | CE | ESE | |
| 3 | - | 2 | 5 | 40 | 60 | 0 | 0 | 40 | 60 | 200 |

CE: Continuous Evaluation, ESE: End Semester Exam

**Objective(s) of the course:**

- To provide knowledge on fundamental physico-chemical treatment methods.
- To understand mechanisms and equipment used in various treatment processes.
- To study process integration for effective wastewater treatment.
- To analyze efficiency and limitations of treatment technologies.

**Course Content:**

| Module | Content | Hour | Weightage In % |
|---|---|---|---|
| 1 | **Introduction & Pre-Treatment Methods**<br>Water pollution overview; wastewater sources and characteristics; point and non-point sources; physical treatment methods; preliminary and pre-treatment units; screening and grit removal; flow equalization concepts; hydraulic and organic load balancing; aeration principles and oxygen transfer mechanisms; coagulation and flocculation processes; types of coagulants and flocculants; floc formation, destabilization, and removal efficiency. | 2 | 10 |
| 2 | **Primary Treatment Processes**<br>Principles of primary treatment; sedimentation theory; types of settling (discrete, flocculent, hindered); settling chamber and clarifier design; surface overflow rate; detention time; sludge collection and removal; filtration mechanisms; slow and rapid sand filters; filter media properties; head loss development; backwashing; filtration system design and performance evaluation. | 8 | 20 |
| 3 | **Physico-Chemical Treatment Methods**<br>Physico-chemical treatment principles; adsorption mechanisms; adsorbent materials and activated carbon; adsorption isotherms; ion exchange processes; cation and anion exchange resins; resin regeneration; membrane-based separation technologies; microfiltration, ultrafiltration, | 5 | 10 |

| | | | |
|---|---|---|---|
| | nanofiltration, and reverse osmosis; membrane fouling and cleaning strategies. | | |
| 4 | **Advanced Oxidation Processes (AOPs) – Basics**<br>Introduction to advanced oxidation processes; oxidation mechanisms; generation of hydroxyl radicals; reaction kinetics; chemical oxidation principles; Fenton process fundamentals; role of hydrogen peroxide and iron catalysts; catalytic oxidation methods; degradation pathways of organic pollutants; advantages and limitations of AOPs. | 4 | 10 |
| 5 | **Advanced Oxidation Processes (AOPs) – Advanced**<br>Advanced AOP techniques; photo-induced oxidation processes; UV-based treatment systems; UV/$H_2O_2$ processes; photocatalysis and semiconductor catalysts; titanium dioxide applications; sono-chemical treatment; ultrasonic cavitation and sonolysis; electrochemical wastewater treatment; electro-oxidation reactions; energy efficiency and process optimization. | 4 | 10 |
| 6 | **Industrial Wastewater Case Studies**<br>Characteristics of industrial wastewater; case studies from process industries; chemical and allied industries; identification of toxic and high-strength pollutants; selection of appropriate treatment trains; design and operational challenges; sludge generation and management; cost analysis; performance evaluation; industrial effluent standards and compliance. | 8 | 20 |
| 7 | **Emerging Trends in Wastewater Treatment**<br>Overview of emerging wastewater treatment technologies; applications of nanotechnology; nanomaterials and nano-adsorbents; nano-membranes; enhanced mass transfer and reaction rates; hybrid treatment systems; integration of physico-chemical and biological processes; energy-efficient and smart treatment systems; automation and future perspectives. | 5 | 10 |
| 8 | **Regulations & Sustainable Practices**<br>Environmental regulations and wastewater discharge standards; regulatory frameworks and monitoring requirements; environmental compliance strategies; sustainable wastewater management practices; water reuse and recycling; resource recovery; circular economy concepts; zero liquid discharge (ZLD) principles; ZLD system configurations; environmental impact assessment and sustainable development goals. | 4 | 10 |
| | **Total** | **45** | **100** |

**Tutorials**

| Tutorial | Content | Duration (Hours) |
|---|---|---|
| 1 | Identification and classification of wastewater sources; analysis of point vs non-point pollution sources using real-life examples | 2 |
| 2 | Numerical problems on flow equalization and hydraulic load balancing; discussion on aeration requirements | 2 |

| | | |
|---|---|---|
| 3 | Design-based problems on screening, grit removal, and coagulation–flocculation units | 2 |
| 4 | Sedimentation theory problems: settling velocity, detention time, and clarifier performance | 2 |
| 5 | Design of settling tanks and calculation of surface overflow rate with numerical examples | 2 |
| 6 | Filtration system problems: rapid vs slow sand filters, head loss calculation, and backwashing analysis | 2 |
| 7 | Adsorption equilibrium problems using Freundlich and Langmuir isotherms | 2 |
| 8 | Ion exchange resin selection and regeneration calculations for industrial wastewater | 2 |
| 9 | Comparative analysis of membrane processes (MF, UF, NF, RO) for different wastewater streams | 2 |
| 10 | Reaction mechanism and numerical problems related to Fenton oxidation and hydroxyl radical generation | 2 |
| 11 | Case-based discussion on UV/$H_2O_2$, photocatalysis, and electrochemical AOPs | 2 |
| 12 | Energy efficiency and process optimization comparison of advanced AOP techniques | 2 |
| 13 | Industrial wastewater case study: selection of treatment train for chemical/process industries | 2 |
| 14 | Techno-economic evaluation of emerging technologies including nanotechnology and hybrid systems | 2 |
| 15 | Regulatory compliance analysis: CPCB norms, ZLD feasibility, and sustainable wastewater management strategies | 2 |
| | **Total** | **30** |

**Text Book:**

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

**Reference Books:**

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

**Course Evaluation:**

**Theory:**

- Continuous Evaluation consists of two tests, each of 30 marks with a duration of 1 hour.
- Faculty Evaluation consists of 10 marks, as per the guidelines provided by the Course Coordinator.
- End Semester Examination will consist of a comprehensive 60 marks theory exam.

**Tutorials:**

- Continuous Evaluation consists of the performance in tutorials, which should be evaluated out of 10 marks for each tutorial in the next session. The average of these will be converted to 10 marks.
- Internal Viva component of 10 marks based on tutorial understanding and application.
- Tutorial-based assignment/quiz/problem-solving test of 20 marks during the End Semester Evaluation.
- Viva/Oral performance during the End Semester Evaluation carrying 10 marks.

**Course Outcome(s):**

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

| SECH7510 | Physico-Chemical Processes For Wastewater Treatment |
|---|---|
| CO 1 | Explain the principles and applications of coagulation, flocculation, and sedimentation. |
| CO 2 | Analyze and design adsorption, ion exchange, and membrane separation processes. |
| CO 3 | Evaluate the peformance of different treatment units |
| CO 4 | Select suitable physico-chemical methods based on wastewater characteristics |
| CO 5 | Evaluate regulatory and sustainable approaches for wastewater treatment, including ZLD. |

**Mapping of CO with PO**

| SECH7510 | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CO 1 | 3 | 2 | | 2 | | | | | | | |
| CO 2 | 2 | 3 | | 3 | 2 | | | | | | |
| CO 3 | 2 | 3 | 3 | 3 | 3 | | | | | | |
| CO 4 | 1 | 2 | 3 | 2 | 2 | | | | | 2 | |
| CO 5 | | | | | | | | 3 | 3 | 3 | 2 |

**Mapping of CO with PSO**

| SECH7510 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|
| CO 1 | 2 | 2 | 1 |
| CO 2 | 3 | 2 | 2 |
| CO 3 | 3 | 3 | 2 |
| CO 4 | 2 | 3 | 2 |
| CO 5 | 1 | 2 | 3 |

Level of Bloom's Revised Bloom's Taxonomy in Assessment

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

| Module No | Content | RBT Level |
|---|---|---|
| 01 | Introduction & Pre-Treatment Methods | 3,5 |
| 02 | Primary Treatment Processes | 1,4 |
| 03 | Physico-Chemical Treatment Methods | 1,3 |
| 04 | Advanced Oxidation Processes (AOPs) - Basics | 2,6 |
| 05 | Advanced Oxidation Processes (AOPs) - Advanced | 1,5 |
| 06 | Industrial Wastewater Case Studies | 3,4 |
| 07 | Emerging Trends in Wastewater Treatment | 2,4 |
| 08 | Regulations & Sustainable Practices | 3,4 |

## P P Savani University
## School of Engineering
## Department of Chemical Engineering

Course Code: SECH7520
Course Name: Basic Environmental Engineering And Pollution Abatement
Prerequisite Course(s): -

**Teaching & Examination Scheme**

| Teaching Scheme (Hours/Week) | | | | Examination Scheme (Marks) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Theory | Practical | Tutorial | Credit | Theory | | Practical | | Tutorial | | Total |
| | | | | CE | ESE | CE | ESE | CE | ESE | |
| 3 | - | 2 | 5 | 40 | 60 | 0 | 0 | 40 | 60 | 200 |

CE: Continuous Evaluation, ESE: End Semester Exam

**Objective(s) of the course:**

- To introduce basic concepts of environmental engineering.
- To understand types and sources of pollution and their impact.
- To study fundamental control technologies for air, water, and soil pollution.
- To create awareness of environmental laws and sustainable practices.

**Course Content:**

| Module | Content | Hour | Weightage In % |
|---|---|---|---|
| 1 | **Fundamentals of Ecology & Pollution** Ecology and environment; biodiversity; ecosystem services; ecosystem risks; ecological balance; types and sources of pollution; pollutant transmission; atmospheric dispersion; bioaccumulation and biomagnification; food chain contamination; habitat degradation; loss of species diversity; sustainability; environmental compartments (air, water, soil); human health impacts | 2 | 10 |
| 2 | **Environmental Quality Standards** Environmental quality standards; air quality standards; water quality standards; industrial pollution standards; emission standards; effluent discharge limits; criteria pollutants; National Ambient Air Quality Standards (NAAQS); primary and secondary standards; hazardous air pollutants; permissible limits; non-attainment areas; environmental laws and regulations; compliance monitoring; enforcement mechanisms; toxic substances control | 8 | 20 |
| 3 | **Pollution Monitoring & Prevention** Pollution monitoring and prevention; air, water, and waste sampling techniques; solid waste characterization; pollution prevention strategies; source reduction; cleaner production; best management practices (BMPs); water optimization; zero discharge concepts; real-time monitoring; sensors and data | 5 | 10 |

| | | | |
|---|---|---|---|
| | loggers; biological monitoring; risk management; stormwater management; sustainable practices | | |
| 4 | **Air Pollution Control**<br>Air pollution control principles; particulate control technologies; gaseous pollutant removal methods; cyclones; fabric filters; baghouse filters; electrostatic precipitators; wet scrubbers; flue gas desulfurization (FGD); selective catalytic reduction (SCR); low-NOx burners; adsorption; thermal oxidizers; emission reduction strategies; scrubbing efficiency; performance evaluation; industrial case studies | 4 | 10 |
| 5 | **Water & Wastewater Treatment**<br>Drinking water treatment; wastewater treatment systems; primary, secondary, and tertiary treatment; coagulation; flocculation; sedimentation; filtration; disinfection; pathogen inactivation; activated sludge process; advanced treatment processes (reverse osmosis, ozonation); nutrient removal; heavy metal removal; water reuse and recycling | 4 | 10 |
| 6 | **Industrial Pollution Control**<br>Industrial pollution control approaches; general process industries (GPI); sector-specific control methods; waste minimization; cleaner technologies; zero liquid discharge (ZLD); best available techniques (BAT); end-of-pipe treatment; effluent recycling; pollution load reduction; process optimization; environmental management systems (ISO 14001); hazardous substance control; energy efficiency; sustainable industrial practices; air pollution abatement; recycling and reuse | 8 | 20 |
| 7 | **Solid Waste Management**<br>Solid waste management principles; waste hierarchy; source segregation; recycling; composting; landfilling; transformation technologies (incineration, gasification, pyrolysis); anaerobic digestion; hazardous waste management; leachate control; landfill gas capture; waste-to-energy technologies; contaminated site cleanup; sustainable waste management | 5 | 10 |
| 8 | **Emerging Challenges**<br>Emerging environmental challenges; special category wastes; circular economy approaches; regulatory compliance; e-waste, plastic waste, and biomedical waste management; extended producer responsibility (EPR); resource recovery; microplastics pollution; emerging contaminants; sustainable development goals (SDGs); climate change adaptation; green technology adoption; environmental auditing; risk assessment; stakeholder engagement; policy frameworks | 4 | 10 |
| | **Total** | **45** | **100** |

**Tutorials**

| Tutorial | Content | Duration (Hours) |
|---|---|---|
| 1 | Identification of environmental compartments (air, water, soil) and classification of pollution sources with real-life examples | 2 |

| | | |
|---|---|---|
| 2 | Case-based discussion on bioaccumulation, biomagnification, and food chain contamination | 2 |
| 3 | Numerical and conceptual problems on atmospheric dispersion and human health impacts | 2 |
| 4 | Interpretation of air and water quality standards (NAAQS, CPCB norms) using sample data | 2 |
| 5 | Comparison of emission standards and effluent discharge limits for different industries | 2 |
| 6 | Pollution monitoring methods: selection of sampling techniques for air, water, and solid waste | 2 |
| 7 | Cleaner production and pollution prevention strategies for small and medium industries | 2 |
| 8 | Design-oriented problems on particulate control devices (cyclones, ESPs, bag filters) | 2 |
| 9 | Case study on gaseous pollutant control technologies (scrubbers, SCR, FGD) | 2 |
| 10 | Numerical problems on coagulation, sedimentation, and filtration in water treatment | 2 |
| 11 | Comparative analysis of primary, secondary, and tertiary wastewater treatment systems | 2 |
| 12 | Industry-specific pollution control strategies including ZLD and cleaner technologies | 2 |
| 13 | Solid waste management planning: segregation, composting, landfilling, and WtE options | 2 |
| 14 | Hazardous and special waste management (e-waste, plastic, biomedical waste) with EPR concepts | 2 |
| 15 | Environmental audit and sustainability assessment for an industrial facility | 2 |
| | **Total** | **30** |

**Text Book:**

| Title | Author(s) | Publication |
|---|---|---|
| Environmental Pollution Control Engineering | C.S. Rao | New Age International |

**Reference Books:**

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

**Course Evaluation:**

**Theory:**

- Continuous Evaluation consists of two tests, each of 30 marks with a duration of 1 hour.
- Faculty Evaluation consists of 10 marks, as per the guidelines provided by the Course Coordinator.
- End Semester Examination will consist of a comprehensive 60 marks theory exam.

**Tutorials:**

- Continuous Evaluation consists of the performance in tutorials, which should be evaluated out of 10 marks for each tutorial in the next session. The average of these will be converted to 10 marks.
- Internal Viva component of 10 marks based on tutorial understanding and application.
- Tutorial-based assignment/quiz/problem-solving test of 20 marks during the End Semester Evaluation.
- Viva/Oral performance during the End Semester Evaluation carrying 10 marks.

**Course Outcome(s):**

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

| SECH7520 | Basic Environmental Engineering And Pollution Abatement |
|---|---|
| CO 1 | Identify major environmental pollutants and their sources. |
| CO 2 | Explain environmental impacts and control measures. |
| CO 3 | Apply basic treatment principles for pollution abatement. |
| CO 4 | Demonstrate knowledge of environmental regulations and standards. |
| CO 5 | Evaluate sustainable and regulatory approaches for environmental pollution abatement. |

**Mapping of CO with PO**

| SECH7520 | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CO 1 | 3 | 2 | | 2 | | | | | | | |
| CO 2 | 2 | 3 | | 3 | 2 | | | | | | |
| CO 3 | 2 | 3 | 3 | 3 | 3 | | | | | | |
| CO 4 | 1 | 2 | 3 | 2 | 2 | | | | | 2 | |
| CO 5 | | | | | | | | 3 | 3 | 3 | 2 |

**Mapping of CO with PSO**

| SECH7520 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|
| CO 1 | 2 | 2 | 1 |
| CO 2 | 3 | 2 | 2 |
| CO 3 | 3 | 3 | 2 |
| CO 4 | 2 | 3 | 2 |
| CO 5 | 1 | 2 | 3 |

Level of Bloom's Revised Bloom's Taxonomy in Assessment

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

| Module No | Content | RBT Level |
|---|---|---|
| 01 | Fundamentals of Ecology & Pollution | 3,5 |
| 02 | Environmental Quality Standards | 1,4 |
| 03 | Pollution Monitoring & Prevention | 1,3 |
| 04 | Air Pollution Control | 2,6 |
| 05 | Water & Wastewater Treatment | 1,5 |
| 06 | Industrial Pollution Control | 3,4 |
| 07 | Solid Waste Management | 2,4 |
| 08 | Emerging Challenges | 3,4 |

## P P Savani University
## School of Engineering
## Department of Chemical Engineering

Course Code: SECH7530
Course Name: Environmental Quality Monitoring & Analysis
Prerequisite Course(s): -

**Teaching & Examination Scheme**

| Teaching Scheme (Hours/Week) | | | | Examination Scheme (Marks) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Theory | Practical | Tutorial | Credit | Theory | | Practical | | Tutorial | | Total |
| | | | | CE | ESE | CE | ESE | CE | ESE | |
| 3 | - | 2 | 5 | 40 | 60 | 0 | 0 | 40 | 60 | 200 |

CE: Continuous Evaluation, ESE: End Semester Exam

**Objective(s) of the course:**

- To develop understanding of environmental sampling and monitoring techniques.
- To study analytical methods for assessing air, water, and soil quality.
- To learn instrumentation used in environmental analysis.
- To interpret analytical results and assess environmental compliance.

**Course Content:**

| Module | Content | Hour | Weightage In % |
|---|---|---|---|
| 1 | **Introduction to Environmental Fate and Transport** Definition and components of the environment; environmental compartments (air, water, soil, sediment); source–environment–receptor linkage; pollutant release pathways; exposure routes and exposure assessment; acute and chronic exposure; health effects of environmental contaminants; fundamentals of toxicology; dose–response relationships; threshold and non-threshold effects; risk perception and basic environmental risk concepts. | 2 | 10 |
| 2 | **Chemicals of Concern & Equilibrium Partitioning** Classification of chemicals of environmental concern; physicochemical properties affecting environmental behavior; solubility and vapor pressure; Henry's law constant; organic carbon partition coefficient (Koc); octanol–water partition coefficient (Kow); persistence and bioaccumulation potential; equilibrium partitioning theory; phase distribution among air, water, soil, and sediment; implications for transport and exposure. | 8 | 20 |
| 3 | **Environmental Parameters & Monitoring** Environmental monitoring objectives; screening parameters for water quality; biochemical oxygen demand (BOD); chemical oxygen demand (COD); total organic carbon (TOC); total dissolved solids (TDS); monitoring strategies; sampling locations and frequency; quality assurance and quality | 5 | 10 |

| | | | |
|---|---|---|---|
| | control (QA/QC); data reliability; error analysis; interpretation of monitoring data. | | |
| 4 | **Sampling & Analysis Techniques** Principles of environmental sampling; sampling techniques for air, water, soil, and sediment; grab and composite sampling; preservation and storage; sample preparation; analytical techniques for organic contaminants; analytical techniques for inorganic contaminants; instrumental methods; detection limits; interferences and analytical errors. | 4 | 10 |
| 5 | **Introduction to Environmental Transport Models** Need for environmental modeling; basic concepts of fate and transport modeling; mass balance approach; BOX models; assumptions and limitations; steady-state and dynamic models; multimedia transport concepts; linkages between environmental compartments; role of models in prediction and risk assessment. | 4 | 10 |
| 6 | **Atmospheric Dispersion & Mass Transport** Atmospheric transport mechanisms; advection and diffusion processes; Gaussian dispersion model; plume and puff models; source characterization; meteorological influences; intraphase mass transport; interphase mass transfer; air–water and air–solid interfaces; diffusion coefficients; convection coefficients; boundary layer concepts. | 8 | 20 |
| 7 | **Chemical Exchange Mechanisms** Mechanisms of chemical exchange between environmental compartments; air–water exchange processes; volatilization and absorption; sediment–water interactions; resuspension and deposition; soil–air exchange mechanisms; vapor intrusion; factors influencing exchange rates; environmental implications of inter-compartment transfer. | 5 | 10 |
| 8 | **Integrated Transport Models & Case Studies** Integrated environmental transport modeling approaches; coupling of air, water, and soil models; scenario analysis; uncertainty analysis; sensitivity analysis; real-world environmental case studies; industrial and urban contamination scenarios; model application in decision-making; policy and regulatory relevance. | 4 | 10 |
| | **Total** | **45** | **100** |

**Tutorials**

| Tutorial | Content | Duration (Hours) |
|---|---|---|
| 1 | Introduction to Environmental Compartments and Pollutant Pathways | 2 |
| 2 | Source–Environment–Receptor Linkage and Exposure Assessment Problems | 2 |
| 3 | Toxicity, Dose–Response Relationships, and Risk Interpretation | 2 |
| 4 | Physicochemical Properties of Pollutants (Kow, Koc, Henry’s Law) – Numerical Problems | 2 |
| 5 | Equilibrium Partitioning Calculations Across Air–Water–Soil Systems | 2 |

| | | |
|---|---|---|
| 6 | Water Quality Parameters (BOD, COD, TOC, TDS) – Data Interpretation | 2 |
| 7 | Design of Environmental Monitoring Programs and Sampling Frequency | 2 |
| 8 | QA/QC in Environmental Monitoring and Error Analysis | 2 |
| 9 | Sampling Techniques for Air, Water, and Soil – Case-Based Discussion | 2 |
| 10 | Analytical Techniques for Organic and Inorganic Pollutants | 2 |
| 11 | Introduction to Mass Balance and Box Models – Problem Solving | 2 |
| 12 | Atmospheric Dispersion Modeling (Gaussian Plume) – Numerical Examples | 2 |
| 13 | Interphase Mass Transfer and Chemical Exchange Mechanisms | 2 |
| 14 | Integrated Environmental Transport Models – Case Study Analysis | 2 |
| 15 | Regulatory Compliance, Reporting, and Environmental Case Studies | 2 |
| | **Total** | **30** |

**Text Book:**

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

**Reference Books:**

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

**Course Evaluation:**

**Theory:**

- Continuous Evaluation consists of two tests, each of 30 marks with a duration of 1 hour.
- Faculty Evaluation consists of 10 marks, as per the guidelines provided by the Course Coordinator.
- End Semester Examination will consist of a comprehensive 60 marks theory exam.

**Tutorials:**

- Continuous Evaluation consists of the performance in tutorials, which should be evaluated out of 10 marks for each tutorial in the next session. The average of these will be converted to 10 marks.
- Internal Viva component of 10 marks based on tutorial understanding and application.
- Tutorial-based assignment/quiz/problem-solving test of 20 marks during the End Semester Evaluation.
- Viva/Oral performance during the End Semester Evaluation carrying 10 marks.

**Course Outcome(s):**

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

| SECH7530 | Environmental Quality Monitoring & Analysis |
|---|---|
| CO 1 | Perform appropriate sampling for environmental media. |
| CO 2 | Use laboratory instruments and techniques for pollutant analysis. |
| CO 3 | Interpret and analyze environmental data. |
| CO 4 | Prepare technical reports in compliance with regulatory norms. |
| CO 5 | Analyze pollutant fate and transport using environmental modeling approaches. |

**Mapping of CO with PO**

| SECH7530 | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CO 1 | 3 | 2 | | 2 | | | | | | | |
| CO 2 | 2 | 3 | | 3 | 2 | | | | | | |
| CO 3 | 2 | 3 | 3 | 3 | 3 | | | | | | |
| CO 4 | 1 | 2 | 3 | 2 | 2 | | | | | 2 | |
| CO 5 | | | | | | | | 3 | 3 | 3 | 2 |

**Mapping of CO with PSO**

| SECH7530 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|
| CO 1 | 2 | 2 | 1 |
| CO 2 | 3 | 2 | 2 |
| CO 3 | 3 | 3 | 2 |
| CO 4 | 2 | 3 | 2 |
| CO 5 | 1 | 2 | 3 |

Level of Bloom's Revised Bloom's Taxonomy in Assessment

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

| Module No | Content | RBT Level |
|---|---|---|
| 01 | Introduction to Environmental Fate and Transport | 3,5 |
| 02 | Chemicals of Concern & Equilibrium Partitioning | 1,4 |
| 03 | Environmental Parameters & Monitoring | 1,3 |
| 04 | Sampling & Analysis Techniques | 2,6 |
| 05 | Introduction to Environmental Transport Models | 1,5 |
| 06 | Atmospheric Dispersion & Mass Transport | 3,4 |
| 07 | Chemical Exchange Mechanisms | 2,4 |
| 08 | Integrated Transport Models & Case Studies | 3,4 |

**P P Savani University**
**School of Engineering**

## Department of Chemical Engineering

Course Code: SECH7540
Course Name: Environmental Engineering
Prerequisite Course(s): -

**Teaching & Examination Scheme**

| Teaching Scheme (Hours/Week) | | | | Examination Scheme (Marks) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Theory | Practical | Tutorial | Credit | Theory | | Practical | | Tutorial | | Total |
| | | | | CE | ESE | CE | ESE | CE | ESE | |
| 3 | - | 2 | 5 | 40 | 60 | 0 | 0 | 40 | 60 | 200 |

CE: Continuous Evaluation, ESE: End Semester Exam

**Objective(s) of the course:**

- To study engineering principles related to water supply, sanitation, and waste management.
- To understand the design and operation of treatment systems.
- To learn about integrated environmental management systems.
- To promote sustainable engineering practices in environmental applications.

**Course Content:**

| Module | Content | Hour | Weightage In % |
|---|---|---|---|
| 1 | **Introduction to Environmental Pollution** Concept and definition of environment; types of industrial pollution; sources of air, water, noise, and solid pollution; emission and effluent characterization; physical, chemical, and biological properties of industrial wastes; environmental quality parameters; overview of environmental laws and standards related to air, water, and noise pollution; role of regulatory bodies; importance of pollution control in industrial development. | 2 | 10 |
| 2 | **Pollution Prevention Strategies** Principles of pollution prevention; process modification techniques; cleaner production concepts; selection of raw material alternatives; waste reduction at source; waste recovery and recycling methods; application of material balance and energy balance in pollution control; water minimization strategies; leak detection and control; process integration for resource conservation; economic and environmental benefits of prevention strategies. | 8 | 20 |
| 3 | **Air Pollution Control Technologies** Fundamentals of air pollution control; particulate matter characteristics; cyclone separators; electrostatic precipitators; wet and dry scrubbers; gaseous pollutant control; absorption and adsorption techniques; design considerations for air pollution control equipment; efficiency | 5 | 10 |

| | | | |
|---|---|---|---|
| | evaluation; pressure drop and energy requirements; industrial applications. | | |
| 4 | **Water Pollution Control - Physical Treatment**<br>Water pollution sources and characteristics; physical treatment processes; pre-treatment methods; screening and grit removal; sedimentation principles; design of settling tanks; filtration methods; centrifugation techniques; coagulation and flocculation mechanisms; chemicals used; treatment efficiency and limitations. | 4 | 10 |
| 5 | **Biological Wastewater Treatment**<br>Principles of biological treatment; biodegradation mechanisms; aerobic treatment systems; anaerobic treatment systems; activated sludge process; trickling filters; aeration methods; oxygen transfer; sludge handling and drying; advantages and limitations of biological treatment processes. | 4 | 10 |
| 6 | **Solid Waste Management**<br>Types and characteristics of solid waste; industrial and municipal solid waste; waste collection and segregation; composting methods; sanitary landfilling principles; landfill design and leachate control; thermal treatment methods; incineration and gasification; energy recovery; briquetting technology; environmental impacts of solid waste management. | 8 | 20 |
| 7 | **Emerging Technologies**<br>Overview of emerging pollution control technologies; advanced oxidation processes; principles and applications; zero liquid discharge systems; ZLD process configurations; concentrate management; circular economy concepts; industrial symbiosis; resource efficiency; future trends in pollution control engineering. | 5 | 10 |
| 8 | **Case Studies & Regulatory Compliance**<br>Industry-specific pollution control case studies; implementation of pollution control technologies; CPCB guidelines and standards; environmental compliance strategies; environmental auditing procedures; monitoring and reporting; non-compliance issues; role of audits in environmental management systems. | 4 | 10 |
| | **Total** | **45** | **100** |

**Tutorials**

| Tutorial | Content | Duration (Hours) |
|---|---|---|
| 1 | Overview of Environmental Pollution: Types, Sources, and Industrial Waste Characteristics | 2 |
| 2 | Environmental Quality Parameters and Regulatory Standards (Air, Water, Noise) | 2 |
| 3 | Pollution Prevention and Cleaner Production – Conceptual Problems | 2 |
| 4 | Material and Energy Balance Applications in Pollution Prevention | 2 |
| 5 | Design and Performance Evaluation of Cyclones and ESPs | 2 |

| | | |
|---|---|---|
| 6 | Scrubbers and Gas Absorption Systems – Numerical Problems | 2 |
| 7 | Physical Water Treatment Units: Sedimentation and Filtration Design | 2 |
| 8 | Coagulation and Flocculation – Jar Test Analysis and Case Studies | 2 |
| 9 | Biological Treatment Systems: Activated Sludge and Trickling Filters | 2 |
| 10 | Aeration Systems and Oxygen Transfer Calculations | 2 |
| 11 | Solid Waste Characterization and Collection System Planning | 2 |
| 12 | Sanitary Landfill Design, Leachate Control, and Energy Recovery | 2 |
| 13 | Emerging Technologies: AOPs, ZLD, and Circular Economy Concepts | 2 |
| 14 | Industrial Pollution Control Case Studies and CPCB Compliance | 2 |
| 15 | Environmental Auditing, Monitoring, and Sustainability Assessment | 2 |
| | **Total** | **30** |

**Text Book:**

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

**Reference Books:**

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

**Course Evaluation:**

**Theory:**

- Continuous Evaluation consists of two tests, each of 30 marks with a duration of 1 hour.
- Faculty Evaluation consists of 10 marks, as per the guidelines provided by the Course Coordinator.
- End Semester Examination will consist of a comprehensive 60 marks theory exam.

**Tutorials:**

- Continuous Evaluation consists of the performance in tutorials, which should be evaluated out of 10 marks for each tutorial in the next session. The average of these will be converted to 10 marks.
- Internal Viva component of 10 marks based on tutorial understanding and application.
- Tutorial-based assignment/quiz/problem-solving test of 20 marks during the End Semester Evaluation.
- Viva/Oral performance during the End Semester Evaluation carrying 10 marks.

**Course Outcome(s):**

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

| SECH7540 | Environmental Engineering |
|---|---|
| CO 1 | Design and analyze water and wastewater treatment processes. |
| CO 2 | Understand the principles of solid waste and air pollution control. |
| CO 3 | Apply engineering solutions to environmental problems. |
| CO 4 | Integrate environmental and sustainability principles in engineering design. |
| CO 5 | Apply principles of cleaner production, circular economy, and sustainability to design and evaluate pollution control and environmental management systems. |

**Mapping of CO with PO**

| SECH7540 | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CO 1 | 3 | 2 | | 2 | | | | | | | |
| CO 2 | 2 | 3 | | 3 | 2 | | | | | | |
| CO 3 | 2 | 3 | 3 | 3 | 3 | | | | | | |
| CO 4 | 1 | 2 | 3 | 2 | 2 | | | | | 2 | |
| CO 5 | | | | | | | | 3 | 3 | 3 | 2 |

**Mapping of CO with PSO**

| SECH7540 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|
| CO 1 | 2 | 2 | 1 |
| CO 2 | 3 | 2 | 2 |
| CO 3 | 3 | 3 | 2 |
| CO 4 | 2 | 3 | 2 |
| CO 5 | 1 | 2 | 3 |

Level of Bloom's Revised Bloom's Taxonomy in Assessment

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

| Module No | Content | RBT Level |
|---|---|---|
| 01 | Introduction to Environmental Pollution | 3,5 |
| 02 | Pollution Prevention Strategies | 1,4 |
| 03 | Air Pollution Control Technologies | 1,3 |
| 04 | Water Pollution Control - Physical Treatment | 2,6 |
| 05 | Biological Wastewater Treatment | 1,5 |
| 06 | Solid Waste Management | 3,4 |
| 07 | Emerging Technologies | 2,4 |
| 08 | Case Studies & Regulatory Compliance | 3,4 |

## Department of Chemical Engineering

Course Code: SECH7550
Course Name: Fuel And Combustion Technology
Prerequisite Course(s): -

**Teaching & Examination Scheme**

| Teaching Scheme (Hours/Week) | | | | Examination Scheme (Marks) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Theory | Practical | Tutorial | Credit | Theory | | Practical | | Tutorial | | Total |
| | | | | CE | ESE | CE | ESE | CE | ESE | |
| 3 | - | 2 | 5 | 40 | 60 | 0 | 0 | 40 | 60 | 200 |

CE: Continuous Evaluation, ESE: End Semester Exam

**Objective(s) of the course:**

- To understand the properties and classifications of fuels.
- To study combustion principles and thermodynamics.
- To evaluate combustion systems and fuel performance.
- To learn pollutant formation and emission control in combustion processes.

**Course Content:**

| Module | Content | Hour | Weightage In % |
|---|---|---|---|
| 1 | **Introduction to Fuels**<br>Historical development and origin of fuels; classification of fuels; production and processing routes; global and national fuel scenario; fuel consumption patterns; renewable and non-renewable fuels; fundamental definitions related to fuels; physical and chemical properties of fuels; proximate and ultimate analysis; measurement of fuel properties; calorific value; ignition temperature; ash and moisture content. | 2 | 10 |
| 2 | **Solid Fossil Fuels (Coal):**<br>Coal formation and classification; rank and grade of coal; coal mining methods; surface and underground mining; coal preparation and beneficiation; coal combustion principles; coke making processes; by-product coke ovens; direct and indirect coal liquefaction; Fischer–Tropsch synthesis; coal gasification processes; fixed-bed, fluidized-bed, and entrained-flow gasifiers; environmental aspects of coal utilization. | 8 | 20 |
| 3 | **Liquid Fossil Fuels (Petroleum):**<br>Origin and composition of petroleum; petroleum exploration and reservoir evaluation; drilling methods; crude oil characterization; atmospheric and vacuum distillation; refinery flow schemes; secondary processing units; thermal and catalytic cracking; reforming processes; alkylation and | 5 | 10 |

| | | | |
|---|---|---|---|
| | isomerization; major refinery units; product blending and specifications. | | |
| 4 | **Gaseous Fuels:** Types and properties of gaseous fuels; natural gas production and processing; liquefied petroleum gas (LPG); producer gas and water gas; hydrogen production methods; acetylene generation; calorific value of gaseous fuels; storage and transportation; advantages and limitations; applications in industrial and domestic sectors. | 4 | 10 |
| 5 | **Thermochemistry:** Basic concepts of thermochemistry; thermochemical equations; heat of reaction; heat of combustion; higher and lower calorific values; Hess's law; enthalpy changes; standard states; bond energy concepts; application of thermochemistry to fuel combustion. | 4 | 10 |
| 6 | **Combustion Calculations:** Stoichiometry of combustion reactions; theoretical air requirement; excess air calculations; flue gas composition; determination of calorific value; adiabatic flame temperature; combustion efficiency; mass and energy balance in combustion systems; numerical problems related to solid, liquid, and gaseous fuels. | 8 | 20 |
| 7 | **Combustion Mechanism:** Fundamentals of combustion kinetics; reaction mechanisms in combustion; chain reactions; flame types; premixed and diffusion flames; flame structure; ignition and ignition delay; flammability limits; explosion phenomena; factors affecting combustion rate and stability. | 5 | 10 |
| 8 | **Combustion Appliances:** Types of combustion appliances; industrial burners; furnace design principles; heat transfer in furnaces; internal combustion engines; spark ignition and compression ignition engines; design aspects of combustion equipment; efficiency improvement; emission control in combustion appliances. | 4 | 10 |
| | **Total** | **45** | **100** |

**Tutorials**

| Tutorial | Content | Duration (Hours) |
|---|---|---|
| 1 | Classification of Fuels and Comparative Analysis of Fuel Properties | 2 |
| 2 | Proximate and Ultimate Analysis – Numerical Problems | 2 |
| 3 | Coal Rank, Grade, and Beneficiation Techniques – Case Discussion | 2 |
| 4 | Coke Making and Coal Conversion Processes (Liquefaction & Gasification) | 2 |
| 5 | Environmental Impacts of Coal Utilization and Mitigation Strategies | 2 |
| 6 | Petroleum Crude Characterization and Refinery Flow Diagram Analysis | 2 |
| 7 | Distillation and Secondary Processing Units – Problem Solving | 2 |
| 8 | Gaseous Fuels Properties, Storage, and Safety Aspects | 2 |
| 9 | Thermochemical Equations and Heat of Combustion Calculations | 2 |

| | | |
|---|---|---|
| 10 | Higher and Lower Calorific Value Determination – Numerical Problems | 2 |
| 11 | Stoichiometric Combustion and Theoretical Air Requirement | 2 |
| 12 | Excess Air, Flue Gas Analysis, and Adiabatic Flame Temperature | 2 |
| 13 | Combustion Mechanisms, Flame Types, and Ignition Phenomena | 2 |
| 14 | Design and Performance of Industrial Burners and Furnaces | 2 |
| 15 | Emission Formation, Combustion Efficiency, and Cleaner Fuel Options | 2 |
| | **Total** | **30** |

**Text Book:**

| Title | Author(s) | Publication |
|---|---|---|
| Fuels and Combustion | Samir Sarkar | Universities Press, 3rd Edition |

**Reference Books:**

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

**Course Evaluation:**

**Theory:**

- Continuous Evaluation consists of two tests, each of 30 marks with a duration of 1 hour.
- Faculty Evaluation consists of 10 marks, as per the guidelines provided by the Course Coordinator.
- End Semester Examination will consist of a comprehensive 60 marks theory exam.

**Tutorials:**

- Continuous Evaluation consists of the performance in tutorials, which should be evaluated out of 10 marks for each tutorial in the next session. The average of these will be converted to 10 marks.
- Internal Viva component of 10 marks based on tutorial understanding and application.
- Tutorial-based assignment/quiz/problem-solving test of 20 marks during the End Semester Evaluation.
- Viva/Oral performance during the End Semester Evaluation carrying 10 marks.

**Course Outcome(s):**

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

| SECH7550 | Fuel And Combustion Technology |
|---|---|
| CO 1 | Classify fuels and analyze their properties. |
| CO 2 | Apply combustion equations and analyze energy efficiency. |
| CO 3 | Design basic combustion systems with emission considerations. |
| CO 4 | Evaluate environmental impacts of fuel usage and suggest alternatives. |
| CO 5 | Evaluate sustainable combustion technologies and cleaner fuel options. |

**Mapping of CO with PO**

| SECH7550 | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CO 1 | 3 | 2 | | 2 | | | | | | | |
| CO 2 | 2 | 3 | | 3 | 2 | | | | | | |
| CO 3 | 2 | 3 | 3 | 3 | 3 | | | | | | |
| CO 4 | 1 | 2 | 3 | 2 | 2 | | | | | 2 | |
| CO 5 | | | | | | | | 3 | 3 | 3 | 2 |

**Mapping of CO with PSO**

| SECH7550 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|
| CO 1 | 2 | 2 | 1 |
| CO 2 | 3 | 2 | 2 |
| CO 3 | 3 | 3 | 2 |
| CO 4 | 2 | 3 | 2 |
| CO 5 | 1 | 2 | 3 |

Level of Bloom's Revised Bloom's Taxonomy in Assessment

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

| Module No | Content | RBT Level |
|---|---|---|
| 01 | Introduction to Fuels | 3,5 |
| 02 | Solid Fossil Fuels (Coal) | 1,4 |
| 03 | Liquid Fossil Fuels (Petroleum) | 1,3 |
| 04 | Gaseous Fuels | 2,6 |
| 05 | Thermochemistry: | 1,5 |
| 06 | Combustion Calculations | 3,4 |
| 07 | Combustion Mechanism | 2,4 |
| 08 | Combustion Appliances | 3,4 |

**P P Savani University**
**School of Engineering**
**Department of Chemical Engineering**

Course Code: SECH7560
Course Name: Optimization in Chemical Engineering
Prerequisite Course(s): -

**Teaching & Examination Scheme**

| Teaching Scheme (Hours/Week) | | | | Examination Scheme (Marks) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Theory | Practical | Tutorial | Credit | Theory | | Practical | | Tutorial | | Total |
| | | | | CE | ESE | CE | ESE | CE | ESE | |
| 3 | - | 2 | 5 | 40 | 60 | 0 | 0 | 40 | 60 | 200 |

CE: Continuous Evaluation, ESE: End Semester Exam

**Objective(s) of the course:**

- To introduce basic concepts of optimization in chemical processes.
- To develop mathematical models for process optimization.
- To apply optimization techniques in design and operation.
- To use software tools for solving engineering optimization problems.

**Course Content:**

| Module | Content | Hour | Weightage In % |
|---|---|---|---|
| 1 | **Introduction to Optimization**: Concept and importance of optimization; scope and role of optimization in engineering decision-making; applications of optimization in chemical engineering systems; classification of optimization problems including linear, nonlinear, integer, mixed-integer, and dynamic optimization; deterministic and stochastic optimization; real-world industrial examples; benefits and limitations of optimization techniques. | 5 | 10 |
| 2 | **Problem Formulation & Basic Concepts**: Steps in optimization problem formulation; identification of decision variables; formulation of objective functions; maximization and minimization problems; equality and inequality constraints; feasible region; convexity concepts; convex and concave sets; convex and concave functions; necessary and sufficient conditions for optimality; graphical interpretation of optimization problems. | 8 | 20 |
| 3 | **Unconstrained Optimization**: Unconstrained optimization problems; single-variable optimization techniques; multivariable optimization; analytical methods using derivatives; numerical optimization approaches; direct search methods; gradient-based methods; Nelder–Mead simplex method; steepest descent method; Newton’s method; convergence behavior and computational considerations. | 5 | 10 |

| | | | |
|---|---|---|---|
| 4 | **Constrained Optimization - Linear Programming**: Linear programming problem formulation; standard and canonical forms; graphical solution methods; simplex method; pivot operations; basic and non-basic variables; duality theory; primal–dual relationships; sensitivity analysis; shadow prices; applications in process and resource optimization. | 5 | 10 |
| 5 | **Constrained Nonlinear Programming**: Nonlinear programming problem formulation; equality and inequality constraints; method of Lagrange multipliers; Karush–Kuhn–Tucker (KKT) conditions; penalty function methods; barrier methods; quadratic programming; numerical solution strategies and practical considerations. | 4 | 10 |
| 6 | **Optimization Algorithms and Tools**: Overview of optimization algorithms; search methods; gradient-based algorithms; second-order methods; evolutionary and nature-inspired algorithms; genetic algorithms; particle swarm optimization; convergence characteristics; stopping criteria; optimization software tools; implementation using MATLAB, LINGO, and Python-based solvers such as Pyomo; comparison of algorithms. | 8 | 20 |
| 7 | **Applications in Chemical Engineering**: Application of optimization techniques in chemical engineering; reactor design and optimization; heat exchanger network optimization; separation process optimization; distillation and absorption systems; process control optimization; scheduling and planning; resource allocation problems; economic and environmental objectives. | 5 | 10 |
| 8 | **Case Studies & Project Work**: Industrial case studies involving optimization; formulation and solution of real-world optimization problems; interpretation of optimization results; multi-objective optimization concepts; Pareto optimality; trade-off analysis; project formulation; presentation and documentation of optimization projects. | 5 | 10 |
| | **Total** | **45** | **100** |

**Tutorials**

| Tutorial | Content | Duration (Hours) |
|---|---|---|
| 1 | Role of Optimization in Chemical Engineering – Industrial Examples and Discussion | 2 |
| 2 | Identification of Decision Variables, Objectives, and Constraints – Practice Problems | 2 |
| 3 | Feasible Region, Convexity, and Graphical Interpretation of Optimization Problems | 2 |
| 4 | Single-Variable Unconstrained Optimization – Analytical Techniques | 2 |
| 5 | Multivariable Optimization Using Gradient and Hessian Concepts | 2 |
| 6 | Numerical Methods for Unconstrained Optimization (Steepest Descent, Newton's Method) | 2 |

| | | |
|---|---|---|
| 7 | Formulation of Linear Programming Problems in Chemical Processes | 2 |
| 8 | Graphical Solution of Linear Programming Problems | 2 |
| 9 | Simplex Method – Step-by-Step Numerical Problems | 2 |
| 10 | Duality and Sensitivity Analysis in Linear Programming | 2 |
| 11 | Constrained Nonlinear Optimization Using Lagrange Multipliers | 2 |
| 12 | Karush–Kuhn–Tucker (KKT) Conditions and Quadratic Programming | 2 |
| 13 | Introduction to Optimization Software Tools (MATLAB / LINGO / Python–Pyomo) | 2 |
| 14 | Optimization Applications in Reactor, Separation, and Utility Systems | 2 |
| 15 | Case Study on Multi-Objective Optimization and Trade-Off Analysis | 2 |
| | **Total** | **30** |

**Text Book:**

| Title | Author(s) | Publication |
|---|---|---|
| Optimization: Theory and Practice | Prof. Debasis Sarkar | NPTEL, IIT Kharagpur (Online Course) |

**Reference Books:**

| Title | Author(s) | Publication |
|---|---|---|
| Introduction to Linear Optimization | Bertsimas and Tsitsiklis | Athena Scientific |
| Nonlinear Programming | Dimitri P. Bertsekas | Athena Scientific |
| Engineering Optimization | R. T. Haese, Kalyanmoy Deb | Wiley / PHI |

**Course Evaluation:**

**Theory:**

- Continuous Evaluation consists of two tests, each of 30 marks with a duration of 1 hour.
- Faculty Evaluation consists of 10 marks, as per the guidelines provided by the Course Coordinator.
- End Semester Examination will consist of a comprehensive 60 marks theory exam.

**Tutorials:**

- Continuous Evaluation consists of the performance in tutorials, which should be evaluated out of 10 marks for each tutorial in the next session. The average of these will be converted to 10 marks.
- Internal Viva component of 10 marks based on tutorial understanding and application.
- Tutorial-based assignment/quiz/problem-solving test of 20 marks during the End Semester Evaluation.
- Viva/Oral performance during the End Semester Evaluation carrying 10 marks.

**Course Outcome(s):**

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

| SECH7560 | Optimization in Chemical Engineering |
|---|---|
| CO 1 | Formulate and solve linear and nonlinear optimization problems. |
| CO 2 | Apply optimization in reactor, separation, and utility systems. |
| CO 3 | Interpret optimization results for process improvement. |
| CO 4 | Use numerical and software tools for decision-making in engineering design. |
| CO 5 | Assess and compare optimization techniques for chemical engineering applications. |

**Mapping of CO with PO**

| SECH7560 | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CO 1 | 3 | 2 | | 2 | | | | | | | |
| CO 2 | 2 | 3 | | 3 | 2 | | | | | | |
| CO 3 | 2 | 3 | 3 | 3 | 3 | | | | | | |
| CO 4 | 1 | 2 | 3 | 2 | 2 | | | | | 2 | |
| CO 5 | | | | | | | | 3 | 3 | 3 | 2 |

**Mapping of CO with PSO**

| SECH7560 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|
| CO 1 | 2 | 2 | 1 |
| CO 2 | 3 | 2 | 2 |
| CO 3 | 3 | 3 | 2 |
| CO 4 | 2 | 3 | 2 |
| CO 5 | 1 | 2 | 3 |

Level of Bloom's Revised Bloom's Taxonomy in Assessment

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

| Module No | Content | RBT Level |
|---|---|---|
| 01 | Introduction to Optimization | 3,5 |
| 02 | Problem Formulation & Basic Concepts | 1,4 |
| 03 | Unconstrained Optimization: | 1,3 |
| 04 | Constrained Optimization - Linear Programming | 2,6 |
| 05 | Constrained Nonlinear Programming | 1,5 |
| 06 | Optimization Algorithms and Tools | 3,4 |
| 07 | Applications in Chemical Engineering | 2,4 |
| 08 | Case Studies & Project Work | 3,4 |

**P P Savani University**
**School of Engineering**

## Department of Computer Engineering

Course Code: SECE7010
Course Name: Mathematical and Numerical Technique in Research
Prerequisite Course(s): -

**Teaching & Examination Scheme**

| Teaching Scheme (Hours/Week) | | | | Examination Scheme (Marks) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Theory | Practical | Tutorial | Credit | Theory | | Practical | | Tutorial | | Total |
| | | | | CE | ESE | CE | ESE | CE | ESE | |
| 3 | 0 | 2 | 5 | 40 | 60 | 0 | 0 | 40 | 60 | 200 |

CE: Continuous Evaluation, ESE: End Semester Exam

**Objective(s) of the course:**

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

**Course Content:**

| Module | Content | Hour | Weightage In % |
|---|---|---|---|
| 1 | **Foundations of Mathematical Modeling in Research** Fundamentals of model formulation and validation, Classification of models: deterministic vs. stochastic, static vs. dynamic, Dimensional analysis and similarity, Applications in chemical process design and computational algorithms | 5 | 10 |
| 2 | **Advanced Linear Algebra and Its Applications** Vector spaces, inner product spaces, Gram-Schmidt orthogonalization, Eigenvalue problems, diagonalization, Jordan forms, Applications in Principal Component Analysis (PCA), process control, and machine learning, Numerical solutions to large systems: Jacobi, Gauss-Seidel methods | 7 | 20 |
| 3 | **Advanced Calculus and Differential Equations** Higher-order ODEs and systems of ODEs, Stability analysis and phase portraits, Laplace transforms and their | 5 | 10 |

| | | | |
|---|---|---|---|
| | applications, Applications in reaction kinetics, control theory, and dynamic system modeling | | |
| 4 | **Partial Differential Equations and Their Numerical Solutions** Heat, wave, and Laplace equations, Method of separation of variables, Fourier and finite difference methods, Finite Volume and Finite Element Methods (FVM, FEM) – introduction and comparison, Applications in mass transfer, CFD, and neural PDE solvers | 5 | 10 |
| 5. | **Numerical Techniques and Scientific Computing** Numerical differentiation and integration: Trapezoidal, Simpson's rule, Root-finding techniques: Newton-Raphson, Secant, Broyden's method, Interpolation and curve fitting, Software implementation using MATLAB, Python, Octave | 5 | 10 |
| 6. | **Optimization Techniques in Research** Classical and non-classical optimization, Linear, Non-linear, Constrained, and Unconstrained optimization, Metaheuristic algorithms: Genetic Algorithms, PSO, Simulated Annealing, Multivariable optimization problems in process design and machine learning | 8 | 20 |
| 7. | **Probability, Statistics, and Data-Driven Modeling** Probability distributions and random variables, Estimation, hypothesis testing, confidence intervals, Regression modeling, ANOVA, Bayesian inference, Applications in process monitoring, reliability engineering, and AI/ML | 5 | 10 |
| 8. | **Computational Tools and Research Applications** Research-centric use of MATLAB, Python (NumPy, SciPy, SymPy, Pandas, Scikit-learn), Aspen Plus, ANSYS Fluent; TensorFlow, PyTorch , Error analysis, reproducibility, and scientific documentation Capstone Project: Solving a real-life or simulated research problem | 5 | 10 |
| | **Total** | 45 | 100 |

**List of Tutorials**

| Tutorial | Content | Duration (Hours) |
|---|---|---|
| 1 | Fundamentals of model formulation and validation; classification of models (deterministic vs. stochastic, static vs. dynamic) | 2 |
| 2 | Dimensional analysis, similarity; applications in chemical process design and computational algorithms | 2 |
| 3 | Vector spaces, inner product spaces, Gram-Schmidt orthogonalization | 2 |
| 4 | Eigenvalue problems, diagonalization, Jordan forms; applications in PCA and process control | 2 |
| 5 | Higher-order ODEs, systems of ODEs; stability analysis and phase portraits | 2 |
| 6 | Laplace transforms; applications in reaction kinetics and control theory | 2 |
| 7 | Heat, wave, and Laplace equations; method of separation of variables | 2 |
| 8 | Fourier, finite difference, FVM, FEM methods; applications in mass transfer and CFD | 2 |

| | | |
|---|---|---|
| 9 | Numerical differentiation, integration (Trapezoidal, Simpson's rule); root-finding (Newton-Raphson, Secant) | 2 |
| 10 | Interpolation, curve fitting; implementation in MATLAB, Python, Octave | 2 |
| 11 | Classical and non-classical optimization; linear and non-linear optimization | 2 |
| 12 | Metaheuristic algorithms (Genetic Algorithms, PSO, Simulated Annealing); multivariable optimization | 2 |
| 13 | Probability distributions, random variables; estimation, hypothesis testing | 2 |
| 14 | Regression modeling, ANOVA, Bayesian inference; applications in process monitoring | 2 |
| 15 | MATLAB, Python (NumPy, SciPy, Pandas, Scikit-learn), Aspen Plus, ANSYS Fluent; capstone project | 4 |
| | **Total** | 30 |

**Text Book:**

| Title | Author(s) | Publication |
|---|---|---|
| Numerical Methods for Engineers | Steven C. Chapra, Raymond P. Canale | McGraw Hill Education |

**Reference Books:**

| Title | Author(s) | Publication |
|---|---|---|
| Applied Numerical Methods with MATLAB for Engineers and Scientists | Steven C. Chapra | McGraw Hill Education |
| n Introduction to Statistical Learning: with Applications in R | Gareth James, Daniela Witten, Trevor Hastie, Robert Tibshirani | Springer |

**Course Evaluation:**

**Theory:**

- Continuous Evaluation consists of two tests, each of 30 marks with a duration of 1 hour.
- Faculty Evaluation consists of 10 marks, as per the guidelines provided by the Course Coordinator.
- End Semester Examination will consist of a comprehensive 60 marks theory exam.

**Tutorials:**

- Continuous Evaluation consists of the performance in tutorials, which should be evaluated out of 10 marks for each tutorial in the next session. The average of these will be converted to 10 marks.
- Internal Viva component of 10 marks based on tutorial understanding and application.
- Tutorial-based assignment/quiz/problem-solving test of 20 marks during the End Semester Evaluation.
- Viva/Oral performance during the End Semester Evaluation carrying 10 marks.

**Course Outcome(s):**

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

| SECE7010 | Mathematical and Numerical Technique in Research |
|---|---|
| CO 1 | Apply advanced mathematical modeling techniques to represent and analyze complex research problems in various engineering domains. |
| CO 2 | Implement and evaluate various numerical methods for solving linear and nonlinear equations, differential equations, and optimization problems using appropriate computational tools. |
| CO 3 | Analyze and interpret experimental or simulated data using statistical and probabilistic methods for informed decision-making in research applications. |
| CO 4 | Develop and validate research-oriented computational models using modern software platforms (e.g., MATLAB, Python, Aspen Plus) and communicate findings effectively through technical documentation and presentations. |
| CO 5 | Integrate interdisciplinary approaches, ethical practices, and sustainability principles in developing innovative mathematical and computational research solutions. |

**Mapping of CO with PO**

| SECE7010 | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CO 1 | 3 | 3 | | 2 | | | | | | | 2 |
| CO 2 | 3 | 3 | | 2 | 3 | | | | | | 2 |
| CO 3 | 3 | 3 | | 3 | 2 | | | | | | 2 |
| CO 4 | 2 | 2 | | 2 | 3 | | | | 3 | | 2 |
| CO 5 | 2 | | 2 | | | 3 | 3 | 2 | | 2 | 2 |

**Mapping of CO with PSO**

| SECE7010 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|
| CO 1 | 3 | 2 | 2 |
| CO 2 | 3 | 3 | 2 |
| CO 3 | 2 | 3 | 2 |
| CO 4 | 3 | 3 | 2 |
| CO 5 | 2 | 3 | 3 |

Level of Bloom's Revised Bloom's Taxonomy in Assessment

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

| Module No | Content | RBT Level |
|---|---|---|
| 01 | Foundations of Mathematical Modeling in Research | 3,5 |
| 02 | Advanced Linear Algebra and Its Applications | 1,4 |
| 03 | Advanced Calculus and Differential Equations | 1,3 |
| 04 | Partial Differential Equations and Their Numerical Solutions | 2,6 |
| 05 | Numerical Techniques and Scientific Computing | 1,5 |

| | | |
|---|---|---|
| 06 | Optimization Techniques in Research | 3,4 |
| 07 | Probability, Statistics, and Data-Driven Modeling | 2,4 |
| 08 | Computational Tools and Research Applications | 3,5 |

**P P Savani University**
**School of Engineering**

## Department of Chemical Engineering

Course Code: SECH7920
Course Name: Research Project-II
Prerequisite Course/s: -

**Teaching & Examination Scheme:**

| Teaching Scheme (Hours/Week) | | | | Examination Scheme (Marks) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Theory | Practical | Tutorial | Credit | Theory | | Practical | | Tutorial | | Total |
| | | | | CE | ESE | CE | ESE | CE | ESE | |
| - | 10 | - | 10 | - | - | 80 | 120 | - | - | 200 |

CE: Continuous Evaluation, ESE: End Semester Exam

**Objective(s) of the course:**

To help learners to

- To engage students in identifying, formulating, and solving real-world research problems.
- To encourage independent and original thinking in designing, implementing, and evaluating computational methods.
- To promote the use of research methodology, scientific writing, and effective communication of results.

**List of Practical's:**

| Sr. No. | Name of Practical | Hours |
|---|---|---|
| 1. | Orientation, topic finalization, and problem statement definition. | 10 |
| 2. | Literature review using IEEE/ACM/ScienceDirect databases. | 20 |
| 3 | Identification of research gap and formulation of research objectives. | 10 |
| 4 | Selection of methodology, tools, and technologies. | 10 |
| 5 | Initial prototype design or dataset collection/preprocessing. | 10 |
| 6 | Core development: algorithm/model/system design begins. | 10 |
| 7 | Implementation continues with performance testing. | 30 |
| 8 | Experimentation, result collection, tuning. | 20 |
| 9 | Result validation (graphs, statistical methods, comparisons). | 20 |
| 10 | Drafting research report/paper, presentation preparation | 10 |
| | **TOTAL** | **150** |

**Practical:**

- Each student should be assigned a faculty guide.
- Regular weekly review meetings are mandatory.
- Mid-term internal evaluation and final external viva should be scheduled.
- Research should ideally be aligned with current thrust areas: chemical engineering, material science etc.

**Course Outcome(s):**

After the completion of the course, the student will be able to

| SECH7920 | Research Project-II |
|---|---|
| CO1 | Identify and define a research problem with reference to current trends in Chemical Engineering. |
| CO2 | Analyze relevant literature and select appropriate tools and techniques. |
| CO3 | Develop and implement innovative solutions or models for real-world problems. |
| CO4 | Evaluate research findings and present technical documentation and publications. |
| CO 5 | Exhibit professional ethics, teamwork, and project management skills in executing a research project. |

**Mapping of CO with PO**

| SECH7920 | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CO 1 | 3 | 2 | | 2 | | | | | | | |
| CO 2 | 2 | 3 | | 3 | 2 | | | | | | |
| CO 3 | 2 | 3 | 3 | 3 | 3 | | | | | | |
| CO 4 | 1 | 2 | 3 | 2 | 2 | | | | | 2 | |
| CO 5 | | | | | | | | 3 | 3 | 3 | 2 |

**Mapping of CO with PSO**

| SECH7920 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|
| CO 1 | 2 | 2 | 1 |
| CO 2 | 3 | 2 | 2 |
| CO 3 | 3 | 3 | 2 |
| CO 4 | 2 | 3 | 2 |
| CO 5 | 1 | 2 | 3 |

**P P Savani University**
**School of Engineering**

**Department of Chemical Engineering**

Course Code: SECH7570
Course Name: Chemical Process Intensification
Prerequisite Course(s): -

**Teaching & Examination Scheme**

| Teaching Scheme (Hours/Week) | | | | Examination Scheme (Marks) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Theory | Practical | Tutorial | Credit | Theory | | Practical | | Tutorial | | Total |
| | | | | CE | ESE | CE | ESE | CE | ESE | |
| 3 | - | 2 | 5 | 40 | 60 | 0 | 0 | 40 | 60 | 200 |

CE: Continuous Evaluation, ESE: End Semester Exam

**Objective(s) of the course:**

- To introduce the principles, philosophy, and need for Chemical Process Intensification (CPI) in modern chemical engineering.
- To enable students to understand intensified equipment, novel reactors, high-efficiency contactors, and hybrid separation systems.
- To impart knowledge on miniaturization, modularization, and energy-efficient process design strategies.
- To develop skills in evaluating intensified processes using modelling, simulation, and sustainability metrics.
- To enable students to design intensified chemical processes considering safety, cost, energy efficiency, and environmental impact.

**Course Content:**

| Module | Content | Hour | Weightage In % |
|---|---|---|---|
| 1 | **Introduction to Process Intensification** Process intensification definition, philosophy of PI, miniaturization, modularization, sustainability, green chemistry, energy efficiency, equipment reduction, batch-to-continuous transition, intensified transport phenomena, process simplification, process intensification metrics, atom economy, eco-efficiency, intensification strategies, scaling laws, NPTEL introduction to CPI. | 5 | 10 |
| 2 | **Intensified Heat and Mass Transfer Operations** Heat transfer intensification, microchannel heat exchangers, compact heat exchangers, enhanced boiling surfaces, rotating packed beds, high-gravity equipment, vortex devices, turbulent promoters, static mixers, intensified evaporators, intensified crystallizers, membrane-assisted evaporation, intensified mass transfer, mass-transfer coefficients, heat-transfer enhancement, NPTEL high-gravity contactors. | 7 | 20 |
| 3 | **Novel and Multifunctional Reactors** | 5 | 10 |

| | | | |
|---|---|---|---|
| | Multifunctional reactors, reactive distillation, reactive absorption, membrane reactors, microreactors, spinning disk reactors, oscillatory baffled reactors, fluid–solid multiphase intensification, catalyst-coated microchannels, photocatalytic reactors, plasma reactors, ultrasound reactors, microwave reactors, structured catalysts, NPTEL intensified reactor design. | | |
| 4 | **Hybrid and Novel Separation Processes** Hybrid separations, reactive distillation, extractive distillation, pervaporation, adsorption–membrane hybrids, SMB chromatography, pressure swing distillation, azeotropic separations, high-flux membranes, intensified absorption units, electrochemical separations, advanced fluid separations, simulated moving beds, hybrid membrane–thermal systems, NPTEL hybrid separation systems. | 5 | 10 |
| 5 | **Micro-Systems and Process Miniaturization** Microreactors, microfluidics, micro heat exchangers, lab-on-chip systems, enhanced mixing, low Reynolds number transport, capillary effects, surface-dominated flow, microfabrication, chemical microplants, modular micro-units, local heat removal, rapid kinetics, intensified safety, thermal runaway control, NPTEL microfluidics for CPI. | 5 | 10 |
| 6 | **Intensification through Alternative Energy Sources** Microwave heating, ultrasound-assisted reactions, plasma-assisted processing, photochemical activation, electrochemical intensification, renewable energy integration, high-frequency heating, energy-efficient catalysis, non-thermal plasma, solar-thermal intensification, photocatalysis, hybrid energy–process units, green energy-driven intensification, NPTEL advanced energy integration. | 8 | 20 |
| 7 | **Safety, Sustainability, Economic Analysis of PI** Intrinsic safety, hazard minimization, safety-by-design, LCA analysis, sustainability metrics, economic feasibility, capital reduction, modular plant economics, cost–benefit analysis, carbon footprint reduction, energy audit, waste minimization, environmental impact assessment, intensified safety characteristics, NPTEL CPI sustainability. | 5 | 10 |
| 8 | **Design, Simulation, and Industrial Applications of PI** Aspen Plus simulation, CFD modeling, reactor modeling, PI design tools, hybrid flowsheet design, industrial intensified equipment, microreactor industries, rotating packed bed industries, reactive distillation case studies, green process design, digital twins, process modeling, pilot-scale intensification, NPTEL intensification case studies. | 5 | 10 |
| | **Total** | 45 | 100 |

**Tutorials**

| Tutorial | Content | Duration (Hours) |
|---|---|---|
| 1 | Introduction to CPI philosophy, need, and scope | 2 |
| 2 | Comparison of conventional vs intensified processes | 2 |

| | | |
|---|---|---|
| 3 | Case study: Rotating packed beds (design + calculations) | 2 |
| 4 | Microreactor design calculations and mixing characteristics | 2 |
| 5 | Hybrid reactive–separation units | 2 |
| 6 | Mass transfer enhancement techniques | 2 |
| 7 | Heat transfer intensification in compact exchangers | 2 |
| 8 | Aspen simulation of reactive distillation | 2 |
| 9 | Membrane reactor modeling (basics) | 2 |
| 10 | Ultrasound and microwave assisted reactors | 2 |
| 11 | Economic evaluation of intensified plant | 2 |
| 12 | Energy analysis using PI metrics | 2 |
| 13 | Sustainability evaluation (LCA case study) | 2 |
| 14 | Industrial case studies: Biodiesel, pharma, fine chemicals | 2 |
| 15 | PI-based mini project presentation (viva) | 2 |
| | **Total** | **30** |

**Text Book:**

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

**Reference Books:**

| Title | Author(s) | Publication |
|---|---|---|
| Process Intensification: Engineering for Efficiency, Sustainability and Flexibility | David Reay, Colin Ramshaw, Adam Harvey | Butterworth-Heinemann (2013) |
| Microreactors in Organic Synthesis and Catalysis | Thomas Wirth | Wiley-VCH (2013) |
| Membrane Technology and Applications | Richard W. Baker | Wiley (2004) |

**Course Evaluation:**

**Theory:**

- Continuous Evaluation consists of two tests, each of 30 marks with a duration of 1 hour.
- Faculty Evaluation consists of 10 marks, as per the guidelines provided by the Course Coordinator.
- End Semester Examination will consist of a comprehensive 60 marks theory exam.

**Tutorials:**

- Continuous Evaluation consists of the performance in tutorials, which should be evaluated out of 10 marks for each tutorial in the next session. The average of these will be converted to 10 marks.
- Internal Viva component of 10 marks based on tutorial understanding and application.
- Tutorial-based assignment/quiz/problem-solving test of 20 marks during the End Semester Evaluation.
- Viva/Oral performance during the End Semester Evaluation carrying 10 marks.

**Course Outcome(s):**

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

| SECH7570 | Chemical Process Intensification |
|---|---|
| CO 1 | Explain the fundamentals, philosophy, and need of process intensification in modern chemical industries. |
| CO 2 | Analyze intensified heat/mass transfer equipment, multifunctional reactors, and hybrid separation systems. |
| CO 3 | Design and evaluate microreactors, alternative energy-assisted reactors, and compact unit operations. |
| CO 4 | Assess and optimize intensified processes through modeling, simulation, sustainability, and economic metrics. |
| CO 5 | Apply PI concepts to industrial processes for safer, greener, and cost-effective chemical manufacturing. |

**Mapping of CO with PO**

| SECH7570 | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CO 1 | 3 | 2 | | 2 | | | | | | | |
| CO 2 | 2 | 3 | | 3 | 2 | | | | | | |
| CO 3 | 2 | 3 | 3 | 3 | 3 | | | | | | |
| CO 4 | 1 | 2 | 3 | 2 | 2 | | | | | 2 | |
| CO 5 | | | | | | | | 3 | 3 | 3 | 2 |

**Mapping of CO with PSO**

| SECH7570 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|
| CO 1 | 2 | 2 | 1 |
| CO 2 | 3 | 2 | 2 |
| CO 3 | 3 | 3 | 2 |
| CO 4 | 2 | 3 | 2 |
| CO 5 | 1 | 2 | 3 |

Level of Bloom's Revised Bloom's Taxonomy in Assessment

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

| Module No | Content | RBT Level |
|---|---|---|
| 01 | Introduction to Process Intensification | 3,5 |
| 02 | Intensified Heat and Mass Transfer Operations | 1,4 |
| 03 | Novel and Multifunctional Reactors | 1,3 |
| 04 | Hybrid and Novel Separation Processes | 2,6 |
| 05 | Micro-Systems and Process Miniaturization | 1,5 |
| 06 | Intensification through Alternative Energy Sources | 3,4 |
| 07 | Safety, Sustainability, Economic Analysis of PI | 2,4 |
| 08 | Design, Simulation, and Industrial Applications of PI | 3,4 |

**P P Savani University**
**School of Engineering**

## Department of Chemical Engineering

Course Code: SECH7580
Course Name: Novel Separation Processes
Prerequisite Course(s): -

**Teaching & Examination Scheme**

| Teaching Scheme (Hours/Week) | | | | Examination Scheme (Marks) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Theory | Practical | Tutorial | Credit | Theory | | Practical | | Tutorial | | Total |
| | | | | CE | ESE | CE | ESE | CE | ESE | |
| 3 | - | 2 | 5 | 40 | 60 | 0 | 0 | 40 | 60 | 200 |

CE: Continuous Evaluation, ESE: End Semester Exam

**Objective(s) of the course:**

- To familiarize students with modern, emerging, and non-conventional separation technologies used in chemical, biochemical, and environmental industries.
- To develop an understanding of mass transfer mechanisms, thermodynamic driving forces, and selectivity principles governing novel separations.
- To impart knowledge on membrane-based, adsorptive, chromatographic, supercritical, and energy-efficient separation techniques.
- To train students in the design, sizing, performance evaluation, and optimization of novel separation units using theoretical and computational tools.
- To enable students to apply novel separation technologies in chemical, petrochemical, pharmaceutical, food, and wastewater treatment industries.

**Course Content:**

| Module | Content | Hour | Weightage In % |
|---|---|---|---|
| 1 | **Introduction to Novel Separation Processes**<br>Non-conventional separations, advanced separation techniques, mass transfer mechanisms, selectivity, thermodynamic driving force, diffusivity, permeability, adsorption, partition coefficient, hybrid separation systems, process intensification, energy efficiency, sustainability, separation economics, industrial applications | 5 | 10 |
| 2 | **Membrane Separation Processes**<br>Ultrafiltration, nanofiltration, microfiltration, reverse osmosis, pervaporation, membrane distillation, dialysis, membrane modules, fouling, concentration polarization, transmembrane pressure, membrane materials, selectivity, flux, solvent–membrane interaction | 7 | 20 |
| 3 | **Adsorptive and Ion-Exchange Separations**<br>Adsorption isotherms, Langmuir model, Freundlich isotherm, breakthrough curves, fixed-bed design, pressure swing adsorption (PSA), temperature swing adsorption (TSA), activated carbon, zeolites, metal–organic frameworks | 5 | 10 |

| | | | |
|---|---|---|---|
| | (MOFs), ion-exchange resins, selectivity coefficient, regeneration, sorbent capacity, dispersion effects | | |
| 4 | **Supercritical Fluid Extraction (SFE)**<br>Supercritical $CO_2$, phase equilibrium, critical point, solubility enhancement, cosolvent, extractor design, fractionation, pressure–temperature diagrams, chromatographic separation, supercritical drying, pharmaceutical applications, food processing, diffusivity, mass transfer coefficients, energy-efficient extraction | 5 | 10 |
| 5 | **Chromatographic Separation Processes**<br>Gas chromatography, liquid chromatography, ion chromatography, affinity chromatography, retention time, partition coefficient, stationary phase, mobile phase, band broadening, Van Deemter equation, column efficiency, gradient elution, resolution, peak asymmetry, detector technology | 5 | 10 |
| 6 | **Advanced Distillation and Hybrid Separations**<br>Extractive distillation, azeotropic distillation, reactive distillation, pressure swing distillation, molecular sieving, entrainers, dividing-wall column, hybrid membrane–distillation systems, dehydration, distillation sequencing, thermodynamic constraints, energy reduction, high-purity separations, mass transfer enhancement | 8 | 20 |
| 7 | **Emerging and Bioseparation Techniques**<br>Electrodialysis, forward osmosis, SMB chromatography, ultrasonic separation, cryogenic separation, freeze concentration, liquid–liquid extraction, bioseparations, affinity methods, protein purification, enzyme immobilization, aqueous two-phase systems, magnetic separation, nanotechnology-enabled separations, environmental applications | 5 | 10 |
| 8 | **Process Modeling, Simulation & Optimization in Novel Separations**<br>Process modelling, mathematical modelling, transport equations, mass and energy balances, flux-based models, thermodynamic models, phase equilibrium, membrane modelling, adsorption modelling, chromatography modelling, process simulation, Aspen Plus, MATLAB, COMSOL Multiphysics, optimization methods, multi-objective optimization, energy–purity trade-off, design of experiments (DoE), sensitivity analysis, parameter estimation, model validation, scale-up strategies, techno-economic analysis, process integration, separation sequencing, and overall performance evaluation of novel separation processes. | 5 | 10 |
| | **Total** | **45** | **100** |

**Tutorials**

| Tutorial | Content | Duration (Hours) |
|---|---|---|
| 1 | Introduction to conventional vs novel separation processes | 2 |
| 2 | Mechanisms and driving forces in advanced separations | 2 |
| 3 | Membrane separation classification and applications | 2 |

| | | |
|---|---|---|
| 4 | Membrane fouling modeling and flux calculations | 2 |
| 5 | Adsorption isotherm analysis (Langmuir, Freundlich) | 2 |
| 6 | Breakthrough curve calculation for fixed-bed adsorbers | 2 |
| 7 | PSA and TSA cycle design problems | 2 |
| 8 | Supercritical $CO_2$ extraction design and calculations | 2 |
| 9 | Chromatographic separation principles and efficiency | 2 |
| 10 | Van Deemter equation and column optimization | 2 |
| 11 | Extractive & azeotropic distillation case studies | 2 |
| 12 | Hybrid separation system design problems | 2 |
| 13 | Electrodialysis and forward osmosis calculations | 2 |
| 14 | Bioseparation design: protein purification | 2 |
| 15 | Industrial case studies: petrochemical, pharma, wastewater | 2 |
| | **Total** | **30** |

**Text Book:**

| Title | Author(s) | Publication |
|---|---|---|
| Novel Separation Processes | Kakasani Ramesh, R. Shanthakumar | PHI Publications |

**Reference Books:**

| Title | Author(s) | Publication |
|---|---|---|
| Membrane Technology & Applications | Richard Baker | John Wiley & Sons (2023) |
| Supercritical Fluid Extraction: Technology Applications | Mohamed A. Abdel-Magid | CRC Press |
| Adsorption and Ion Exchange: Principles & Applications | D. M. Ruthven | Elsevier |

**Course Evaluation:**

**Theory:**

- Continuous Evaluation consists of two tests, each of 30 marks with a duration of 1 hour.
- Faculty Evaluation consists of 10 marks, as per the guidelines provided by the Course Coordinator.
- End Semester Examination will consist of a comprehensive 60 marks theory exam.

**Tutorials:**

- Continuous Evaluation consists of the performance in tutorials, which should be evaluated out of 10 marks for each tutorial in the next session. The average of these will be converted to 10 marks.
- Internal Viva component of 10 marks based on tutorial understanding and application.
- Tutorial-based assignment/quiz/problem-solving test of 20 marks during the End Semester Evaluation.
- Viva/Oral performance during the End Semester Evaluation carrying 10 marks.

**Course Outcome(s):**

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

| SECH7580 | Novel Separation Processes |
|---|---|
| CO 1 | Explain the principles, mechanisms, and applications of novel separation processes. |
| CO 2 | Analyze membrane, adsorptive, chromatographic, and hybrid separation systems. |
| CO 3 | Design and evaluate supercritical, advanced distillation, and high-selectivity separation units. |
| CO 4 | Apply novel separation techniques in chemical, petrochemical, pharmaceutical, food, and environmental industries. |
| CO 5 | Critically evaluate process performance, sustainability, and economic feasibility of modern separation technologies. |

**Mapping of CO with PO**

| SECH7580 | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CO 1 | 3 | 2 | | 2 | | | | | | | |
| CO 2 | 2 | 3 | | 3 | 2 | | | | | | |
| CO 3 | 2 | 3 | 3 | 3 | 3 | | | | | | |
| CO 4 | 1 | 2 | 3 | 2 | 2 | | | | | 2 | |
| CO 5 | | | | | | | | 3 | 3 | 3 | 2 |

**Mapping of CO with PSO**

| SECH7580 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|
| CO 1 | 2 | 2 | 1 |
| CO 2 | 3 | 2 | 2 |
| CO 3 | 3 | 3 | 2 |
| CO 4 | 2 | 3 | 2 |
| CO 5 | 1 | 2 | 3 |

Level of Bloom's Revised Bloom's Taxonomy in Assessment

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

| Module No | Content | RBT Level |
|---|---|---|
| 01 | Introduction to Novel Separation Processes | 3,5 |
| 02 | Membrane Separation Processes | 1,4 |
| 03 | Adsorptive and Ion-Exchange Separations | 1,3 |
| 04 | Supercritical Fluid Extraction | 2,6 |
| 05 | Chromatographic Separation Processes | 1,5 |
| 06 | Advanced Distillation and Hybrid Separations | 3,4 |
| 07 | Emerging and Bioseparation Techniques | 2,4 |
| 08 | Process Modelling, Simulation & Optimization in Novel Separations | 3,4 |

**P P Savani University**
**School of Engineering**

**Department of Chemical Engineering**

Course Code: SECH7590
Course Name: Advanced Reaction Engineering
Prerequisite Course(s): -

**Teaching & Examination Scheme**

| Teaching Scheme (Hours/Week) | | | | Examination Scheme (Marks) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Theory | Practical | Tutorial | Credit | Theory | | Practical | | Tutorial | | Total |
| | | | | CE | ESE | CE | ESE | CE | ESE | |
| 3 | - | 2 | 5 | 40 | 60 | 0 | 0 | 40 | 60 | 200 |

CE: Continuous Evaluation, ESE: End Semester Exam

**Objective(s) of the course:**

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

**Course Content:**

| Module | Content | Hour | Weightage In % |
|---|---|---|---|
| 1 | **Advanced Chemical Kinetics and Mechanisms** rate laws, complex reaction networks, chain reactions, polymerization kinetics, enzyme kinetics, Langmuir–Hinshelwood kinetics, Eley–Rideal mechanism, autocatalysis, temperature dependence, Arrhenius law, collision theory, transition state theory, radical reactions, ignition/extinction behaviour, micro-kinetic modelling, reaction pathway analysis. | 5 | 10 |
| 2 | **Non-Ideal Flow and Residence Time Distribution (RTD)** RTD, tracer techniques, tanks-in-series, dispersion model, Peclet number, bypassing, channeling, dead zones, mixing patterns, E-curve, F-curve, non-ideal reactors, model fitting, flow diagnostics, segregation model, micro-mixing, macro-mixing. | 7 | 20 |
| 3 | **Gas–Liquid and Gas–Solid Reactions** mass transfer, film theory, Hatta number, enhancement factor, heterogeneous kinetics, gas absorption, catalytic | 5 | 10 |

| | | | |
|---|---|---|---|
| | reactions, diffusion limitations, Thiele modulus, effectiveness factor, internal diffusion, external mass transfer, reaction regime, two-film theory, wetting efficiency. | | |
| 4 | **Heterogeneous Catalysis and Catalyst Deactivation** catalyst deactivation, poisoning, sintering, coking, fouling, active sites, adsorption isotherms, BET theory, turnover frequency, catalyst regeneration, diffusion limitations, supported catalysts, porous catalysts, micro-kinetic models, reforming catalysts, degradation kinetics. | 5 | 10 |
| 5 | **Advanced Reactor Design and Modelling** PFR, CSTR, packed-bed reactor, fluidized-bed reactor, multiphase reactor modelling, heat effects, adiabatic operation, temperature profiles, energy balance, autothermal reactors, runaway reactions, dynamic modelling, reactor optimization, scale-up criteria, design equations. | 5 | 10 |
| 6 | **Computational Tools and Simulation in Reaction Engineering** MATLAB, Python, Aspen Plus, COMSOL Multiphysics, reactor simulation, parameter estimation, numerical methods, ODE/PDE solvers, computational fluid dynamics (CFD), data fitting, optimization algorithms, kinetic parameter regression, sensitivity analysis, real-time simulation. | 8 | 20 |
| 7 | **Industrial Applications and Case Studies** refinery reactors, polymer reactors, oxidation processes, hydrogenation, ammonia synthesis, reforming units, membrane reactors, bioreactors, wastewater treatment reactions, pharmaceutical synthesis, process safety, scale-up, troubleshooting, process intensification, sustainability. | 5 | 10 |
| 8 | **Emerging Trends in Reaction Engineering** Artificial intelligence and machine learning in kinetics, data-driven modelling, digital twins, green chemistry-driven reactor design, photocatalytic and plasma reactors, microreactors and intensified systems, autonomous reactors, quantum chemistry for mechanism prediction, sustainable process development, advanced sensors and real-time monitoring. | 5 | 10 |
| | **Total** | **45** | **100** |

**Tutorials**

| Tutorial | Content | Duration (Hours) |
|---|---|---|
| 1 | Complex reaction mechanisms, derivation of rate laws | 2 |
| 2 | Temperature dependency and Arrhenius calculations | 2 |
| 3 | Enzyme kinetics and catalytic mechanisms | 2 |
| 4 | RTD experiments, E-curve and F-curve interpretation | 2 |
| 5 | Modelling tanks-in-series and dispersion models | 2 |
| 6 | Gas–liquid reaction regimes and enhancement factors | 2 |
| 7 | Evaluation of Thiele modulus and effectiveness factor | 2 |
| 8 | Catalyst deactivation modelling | 2 |
| 9 | Design of PFR and CSTR for complex reactions | 2 |
| 10 | Non-isothermal reactor design and reactor stability | 2 |

| | | |
|---|---|---|
| 11 | Modelling packed-bed and fluidized-bed reactors | 2 |
| 12 | Simulation of reactors using MATLAB/Python | 2 |
| 13 | Parameter estimation and curve fitting | 2 |
| 14 | Industrial case studies: ammonia synthesis, polymerization | 2 |
| 15 | Troubleshooting and safety analysis in reactors | 2 |

**Text Book:**

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

**Reference Books:**

| Title | Author(s) | Publication |
|---|---|---|
| Chemical Reaction Engineering | Octave Levenspiel | Wiley (1998) |
| Chemical Reactor Analysis and Design | Froment & Bischoff | Wiley (2010) |
| Reactor Design for Chemical Engineers | J.M. Smith | McGraw-Hill (2018) |

**Course Evaluation:**

**Theory:**

- Continuous Evaluation consists of two tests, each of 30 marks with a duration of 1 hour.
- Faculty Evaluation consists of 10 marks, as per the guidelines provided by the Course Coordinator.
- End Semester Examination will consist of a comprehensive 60 marks theory exam.

**Tutorials:**

- Continuous Evaluation consists of the performance in tutorials, which should be evaluated out of 10 marks for each tutorial in the next session. The average of these will be converted to 10 marks.
- Internal Viva component of 10 marks based on tutorial understanding and application.
- Tutorial-based assignment/quiz/problem-solving test of 20 marks during the End Semester Evaluation.
- Viva/Oral performance during the End Semester Evaluation carrying 10 marks.

**Course Outcome(s):**

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

| SECH7590 | Advanced Reaction Engineering |
|---|---|
| CO 1 | Apply advanced kinetic models and mechanistic understanding for complex reaction systems. |
| CO 2 | Analyze non-ideal flow behavior using RTD and diagnose reactor performance issues. |
| CO 3 | Evaluate catalytic/multiphase reaction systems considering mass transfer and diffusion limitations. |

| | |
|---|---|
| CO 4 | Design and model advanced reactors with coupled heat–mass–reaction phenomena. |
| CO 5 | Use computational tools for simulation, optimization, and troubleshooting in industrial reaction engineering. |

**Mapping of CO with PO**

| SECH7590 | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CO 1 | 3 | 2 | | 2 | | | | | | | |
| CO 2 | 2 | 3 | | 3 | 2 | | | | | | |
| CO 3 | 2 | 3 | 3 | 3 | 3 | | | | | | |
| CO 4 | 1 | 2 | 3 | 2 | 2 | | | | | 2 | |
| CO 5 | | | | | | | | 3 | 3 | 3 | 2 |

**Mapping of CO with PSO**

| SECH7590 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|
| CO 1 | 2 | 2 | 1 |
| CO 2 | 3 | 2 | 2 |
| CO 3 | 3 | 3 | 2 |
| CO 4 | 2 | 3 | 2 |
| CO 5 | 1 | 2 | 3 |

Level of Bloom's Revised Bloom's Taxonomy in Assessment

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

| Module No | Content | RBT Level |
|---|---|---|
| 01 | Advanced Chemical Kinetics and Mechanisms | 3,5 |
| 02 | Non-Ideal Flow and Residence Time Distribution (RTD) | 1,4 |
| 03 | Gas–Liquid and Gas–Solid Reactions | 1,3 |
| 04 | Heterogeneous Catalysis and Catalyst Deactivation | 2,6 |
| 05 | Advanced Reactor Design and Modeling | 1,5 |
| 06 | Computational Tools and Simulation in Reaction Engineering | 3,4 |
| 07 | Industrial Applications and Case Studies | 2,4 |
| 08 | Emerging Trends in Reaction Engineering | 3,4 |

## P P Savani University
## School of Engineering
## Department of Chemical Engineering

Course Code: SECH7600
Course Name: Advanced Process Control
Prerequisite Course(s): -

**Teaching & Examination Scheme**

| Teaching Scheme (Hours/Week) | | | | Examination Scheme (Marks) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Theory | Practical | Tutorial | Credit | Theory | | Practical | | Tutorial | | Total |
| | | | | CE | ESE | CE | ESE | CE | ESE | |
| 3 | - | 2 | 5 | 40 | 60 | 0 | 0 | 40 | 60 | 200 |

CE: Continuous Evaluation, ESE: End Semester Exam

**Objective(s) of the course:**

- To provide an in-depth understanding of dynamic modeling, advanced control strategies, and optimization in chemical process systems.
- To equip students with modern techniques including multivariable control, model predictive control (MPC), and adaptive control used in industries.
- To develop the ability to design, tune, and implement advanced controllers using simulation tools such as MATLAB, Simulink, and Python.
- To prepare students for handling complex nonlinear, interacting, and constrained processes through robust and intelligent control methods.
- To strengthen students' analytical capability for diagnostic analysis, stability assessment, and real-time process monitoring and control.

**Course Content:**

| Module | Content | Hour | Weightage In % |
|---|---|---|---|
| 1 | **Process Dynamics, Modeling & System Behavior** Dynamic modeling, linearization, Laplace transforms, transfer functions, interacting systems, non-interacting systems, FOPTD model, SOPTD model, time constants, process gain, dead time, frequency response, Bode plot, Nyquist plot, stability criteria, Routh-Hurwitz, sensitivity analysis, process nonlinearity, dynamic simulation. | 5 | 10 |
| 2 | **Advanced PID Control, Tuning & Industrial Control Structures** PID tuning, Ziegler–Nichols, Cohen–Coon, IMC tuning, cascade control, ratio control, feedforward control, override control, split-range control, selector control, dead-time compensation, Smith predictor, internal model control (IMC), disturbance rejection, anti-reset windup, performance indices, servo vs regulatory response. | 7 | 20 |
| 3 | **Multivariable Control & Interaction Analysis (MIMO Control)** | 5 | 10 |

| | | | |
|---|---|---|---|
| | multivariable systems, MIMO models, RGA (Relative Gain Array), interaction analysis, decouplers, decentralized control, pairing rules, block diagrams, controllability, observability, singular value decomposition, condition number, process interaction, cross-coupling effects, steady-state gain matrix, non-square systems. | | |
| 4 | **Model Predictive Control and Optimization-Based Control** Model Predictive Control, prediction horizon, control horizon, objective function, cost minimization, constraints handling, QP (quadratic programming), dynamic matrix control (DMC), state-space models, stability in MPC, receding horizon control, constraint softening, move suppression, set-point tracking, disturbance modeling, real-time optimization. | 5 | 10 |
| 5 | **Adaptive, Nonlinear & Intelligent Control Systems** adaptive control, gain scheduling, model-reference adaptive control (MRAC), self-tuning regulators, nonlinear control, feedback linearization, Lyapunov stability, fuzzy logic control, neural network control, reinforcement learning-based control, robust control, H-infinity control, sliding mode control, soft sensors, process monitoring. | 5 | 10 |
| 6 | **Digital Control Systems, Sampling & Discrete-Time Modelling** Introduction to digital control, need for digital controllers in process industries, Sampling theory, sampling frequency, aliasing, sample-and-hold mechanisms, Z-transform, properties, region of convergence, Pulse transfer function, digital control algorithm structure, Discrete-time system modelling, difference equations, discrete state-space models, Stability analysis in discrete domain: Jury stability test, Digital PID algorithms (positional, velocity, incremental form), Digital controller implementation issues: quantization, computational delay, data loss, Discrete-time root locus, Bode & Nyquist plot in discrete domain, Design of digital controllers for chemical processes (MATLAB/Python examples) | 8 | 20 |
| 7 | **Process Instrumentation, Actuators & Industrial Automation Systems** Industrial sensors: pressure, temperature, flow, composition, level, Smart sensors, field transmitters (HART, Foundation Fieldbus, Profibus), Actuators: control valves, characteristics, sizing, valve hysteresis, stiction, cavitation, Pneumatic, electric & hydraulic actuators—response and dynamics, PLCs (Programmable Logic Controllers): architecture, ladder programming basics, DCS (Distributed Control Systems): structure, control hierarchy, SCADA systems: data acquisition, communication protocols, Signal conditioning, filtering, noise reduction, calibration, Instrumentation faults, fault detection & diagnosis (FDD), Industrial automation case studies (refinery, polymer plant, distillation column) | 5 | 10 |
| 8 | **Emerging Trends, Industrial Applications & Case Studies in Advanced Control** Digital twins for chemical processes, Industry 4.0 and smart manufacturing, Real-time optimization (RTO) and enterprise | 5 | 10 |

| | | | |
|---|---|---|---|
| | control systems, Advanced control in refineries: crude distillation, FCC, hydrotreaters, MPC in polymer reactors, biochemical processes & batch reactors, AI/ML in process control: prediction models, soft sensors, anomaly detection, Reinforcement learning control for dynamic chemical systems, Big-data analytics for plant-wide monitoring, Cloud-based process control, cybersecurity challenges, Case studies: MPC implementation in distillation, Adaptive control of CSTR, Inferential control of composition, Intelligent fault diagnosis using ML | | |
| | **Total** | **45** | **100** |

**Tutorials**

| Tutorial | Content | Duration (Hours) |
|---|---|---|
| 1 | Basics of process dynamic modelling and linearization | 2 |
| 2 | Transfer function development and time-domain responses | 2 |
| 3 | Frequency response: Bode plot, Nyquist criteria | 2 |
| 4 | PID tuning using ZN, CC, and IMC methods | 2 |
| 5 | Cascade, ratio, and feedforward control problem solving | 2 |
| 6 | Dead-time compensation using Smith predictor & IMC | 2 |
| 7 | Performance indices evaluation (IAE, ISE, ITAE) | 2 |
| 8 | MIMO interaction: RGA, pairing rules | 2 |
| 9 | Decoupler design for 2×2 process | 2 |
| 10 | Introduction to MPC: formulation & constraints | 2 |
| 11 | Dynamic Matrix Control (DMC) example using MATLAB/Python | 2 |
| 12 | Adaptive control (MRAC, STR) calculations | 2 |
| 13 | Nonlinear control: feedback linearization examples | 2 |
| 14 | Fuzzy logic controller design | 2 |
| 15 | Case study: Advanced control in distillation/reformer/reactor | 2 |
| | **Total** | **30** |

**Text Book:**

| Title | Author(s) | Publication |
|---|---|---|
| Process Dynamics and Control | Dale E. Seborg, Thomas F. Edgar, Duncan Mellichamp | Wiley |

**Reference Books:**

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

**Course Evaluation:**

**Theory:**

- Continuous Evaluation consists of two tests, each of 30 marks with a duration of 1 hour.

- Faculty Evaluation consists of 10 marks, as per the guidelines provided by the Course Coordinator.
- End Semester Examination will consist of a comprehensive 60 marks theory exam.

**Tutorials:**

- Continuous Evaluation consists of the performance in tutorials, which should be evaluated out of 10 marks for each tutorial in the next session. The average of these will be converted to 10 marks.
- Internal Viva component of 10 marks based on tutorial understanding and application.
- Tutorial-based assignment/quiz/problem-solving test of 20 marks during the End Semester Evaluation.
- Viva/Oral performance during the End Semester Evaluation carrying 10 marks.

**Course Outcome(s):**

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

| SECH7600 | Advanced Process Control |
|---|---|
| CO 1 | Develop and analyze dynamic models of chemical processes using linear and nonlinear techniques. |
| CO 2 | Apply advanced PID-based and industrial control strategies for improved process performance. |
| CO 3 | Evaluate interactions in multivariable systems and design appropriate MIMO control strategies. |
| CO 4 | Formulate and implement Model Predictive Control (MPC) for constrained and multivariable processes. |
| CO 5 | Design adaptive, nonlinear, and intelligent controllers for complex chemical processes. |

**Mapping of CO with PO**

| SECH7600 | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CO 1 | 3 | 2 | | 2 | | | | | | | |
| CO 2 | 2 | 3 | | 3 | 2 | | | | | | |
| CO 3 | 2 | 3 | 3 | 3 | 3 | | | | | | |
| CO 4 | 1 | 2 | 3 | 2 | 2 | | | | | 2 | |
| CO 5 | | | | | | | | 3 | 3 | 3 | 2 |

**Mapping of CO with PSO**

| SECH7600 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|
| CO 1 | 2 | 2 | 1 |
| CO 2 | 3 | 2 | 2 |
| CO 3 | 3 | 3 | 2 |
| CO 4 | 2 | 3 | 2 |
| CO 5 | 1 | 2 | 3 |

Level of Bloom's Revised Bloom's Taxonomy in Assessment

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

| **Module No** | **Content** | **RBT Level** |
|---|---|---|
| 01 | Process Dynamics, Modeling & System Behavior | 3,5 |
| 02 | Advanced PID Control, Tuning & Industrial Control Structures | 1,4 |
| 03 | Multivariable Control & Interaction Analysis (MIMO Control) | 1,3 |
| 04 | Model Predictive Control and Optimization-Based Control | 2,6 |
| 05 | Adaptive, Nonlinear & Intelligent Control Systems | 1,5 |
| 06 | Digital Control Systems, Sampling & Discrete-Time Modelling | 3,4 |
| 07 | Process Instrumentation, Actuators & Industrial Automation Systems | 2,4 |
| 08 | Emerging Trends, Industrial Applications & Case Studies in Advanced Control | 3,4 |

# P P Savani University
# School of Engineering
## Department of Chemical Engineering

Course Code: SECH7610
Course Name: Soft Nano Technology
Prerequisite Course(s): -

**Teaching & Examination Scheme**

| Teaching Scheme (Hours/Week) | | | | Examination Scheme (Marks) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Theory | Practical | Tutorial | Credit | Theory | | Practical | | Tutorial | | Total |
| | | | | CE | ESE | CE | ESE | CE | ESE | |
| 3 | - | 2 | 5 | 40 | 60 | 0 | 0 | 40 | 60 | 200 |

CE: Continuous Evaluation, ESE: End Semester Exam

**Objective(s) of the course:**

- To provide fundamental and advanced understanding of soft nanomaterials, including polymers, colloids, gels, surfactants, biomolecules, and hybrid soft systems.
- To explore the self-assembly mechanisms, intermolecular forces, and nanoscale interactions governing soft matter behavior.
- To develop knowledge on fabrication, synthesis, and processing methods used in soft nanotechnology applications.
- To familiarize students with characterization techniques essential for analyzing structure, dynamics, and mechanical properties of soft nanomaterials.
- To enable students to understand applications, sustainability, nanotoxicity, and emerging trends in soft nanotechnology relevant to chemical, biomedical, energy, and environmental engineering.

**Course Content:**

| Module | Content | Hour | Weightage In % |
|---|---|---|---|
| 1 | **Introduction to Soft Nanotechnology and Soft Matter Systems**<br>Soft matter definition; soft nanomaterials; polymers; colloids; gels; micelles; emulsions; foams; surfactants; liquid crystals; biomolecules; lipid bilayers; dendrimers; nano micelles; viscoelasticity; Brownian motion; molecular interactions; entropic elasticity; thermal fluctuations; self-assembly in soft structures; NPTEL fundamentals of soft matter. | 5 | 10 |
| 2 | **Intermolecular Interactions & Self-Assembly Mechanisms**<br>Van der Waals forces; hydrogen bonding; electrostatic interactions; steric stabilization; depletion forces; DLVO theory; entropic forces; hydrophobic interactions; surfactant aggregation; critical micelle concentration (CMC); block copolymer self-assembly; nano-templating; molecular recognition; spontaneous ordering; responsive soft materials; | 7 | 20 |

| | | | |
|---|---|---|---|
| | thermotropic and lyotropic phases; supramolecular chemistry; weak-bond networks; hierarchical self-assembly. | | |
| 3 | **Soft Nanomaterials Fabrication & Processing Techniques**<br>Solution processing; sol-gel methods; emulsion polymerization; nano-patterning; lithography basics; layer-by-layer assembly; electrospinning; nano-coating; thin films; hydrogel synthesis; stimuli-responsive polymer fabrication; microfluidic synthesis; biomimetic assembly; colloidal templating; inkjet printing of soft materials; drop-casting; spin-coating; 3D printing of soft matter; soft lithography (PDMS molds, microcontact printing). | 5 | 10 |
| 4 | **Characterization Techniques for Soft Nanomaterials**<br>Dynamic Light Scattering (DLS); Zeta potential; FTIR; UV-Vis spectroscopy; Fluorescence spectroscopy; AFM; TEM; SEM; rheology; viscosity measurement; SAXS/WAXS; NMR; DSC; TGA; DMA; confocal microscopy; particle size analysis; surface charge measurement; molecular weight distribution (GPC); mechanical behavior of soft materials; nanomechanical testing; . | 5 | 10 |
| 5 | **Soft Nanotechnology in Biological & Biomedical Systems**<br>Biopolymers; DNA nanotechnology; protein folding; lipid nanostructures; hydrogels in biomedicine; drug delivery nanocarriers; liposomes; polymeric nanoparticles; tissue engineering scaffolds; biosensing materials; bio-inspired nanostructures; enzyme-assisted assembly; biocompatibility; cell-material interactions; targeted delivery; stimuli-responsive drug systems; nano-bio interactions; soft robotic materials; regenerative medicine. | 5 | 10 |
| 6 | **Applications, Nanotoxicity, Sustainability & Emerging Trends**<br>Green nanotechnology; biodegradable soft nanomaterials; sustainability challenges; environmental impact; nanotoxicology; exposure pathways; regulatory aspects; risk assessment; renewable energy applications; soft electronics; wearable sensors; flexible devices; energy harvesting; environmental remediation; nano-coatings; water purification membranes; soft actuators; smart materials; NPTEL future trends in nano-science; circular materials design. | 8 | 20 |
| 7 | **Soft Nano rheology, Dynamics & Transport Phenomena**<br>Rheology of soft nanomaterials; viscoelastic behavior; linear & nonlinear rheology; time–temperature superposition; relaxation times; creep and stress relaxation; dynamic mechanical analysis principles; micro- and nano-scale flow behavior; diffusion in soft systems; Fickian and non-Fickian transport; osmotic pressure; permeability of soft membranes; transport in gels and polymer networks; role of Brownian motion in particle dynamics; micro rheology (active & passive methods); particle tracking; diffusion coefficient measurement; rheo-optical techniques; deformation and flow of complex fluids; shear thinning/thickening; yield stress materials; thixotropy; nanoconfinement effects on soft material dynamics. | 5 | 10 |

| | | | |
|---|---|---|---|
| 8 | **Computational Modeling, Simulation & Industrial Applications of Soft Nanotechnology**<br>Computational modeling of soft matter; molecular dynamics (MD) simulations; Monte Carlo methods; coarse-grained simulations; dissipative particle dynamics (DPD); mesoscale modeling; CFD for soft matter flows; continuum vs atomistic simulation approaches; multi-scale modeling of polymers, colloids, gels & biomaterials; phase-field modeling; simulation of self-assembly; predictive modeling for soft nanostructures; AI/ML applications in soft nanotechnology; data-driven materials discovery; digital twins for soft materials; industrial case studies—coatings, cosmetics, pharmaceuticals, food engineering, adhesives, packaging; soft nanomaterials scale-up challenges; process design & manufacturing considerations; quality control; industrial standards; techno-economic analysis. | 5 | 10 |
| | **Total** | **45** | **100** |

**Tutorials**

| Tutorial | Content | Duration (Hours) |
|---|---|---|
| 1 | Introduction to soft matter, types, molecular interactions | 2 |
| 2 | Colloids, gels, surfactants, polymeric soft systems | 2 |
| 3 | Self-assembly: micelles, vesicles, block copolymers | 2 |
| 4 | Intermolecular forces & DLVO theory | 2 |
| 5 | Hydrogels & soft nanocomposites | 2 |
| 6 | Fabrication methods – sol-gel, LbL, electrospinning | 2 |
| 7 | Soft lithography and patterning principles | 2 |
| 8 | DLS, zeta potential, particle size analysis | 2 |
| 9 | AFM, SEM, TEM for soft materials | 2 |
| 10 | Rheology & viscoelastic behavior tutorials | 2 |
| 11 | Biological soft materials & biomimetic systems | 2 |
| 12 | Drug delivery soft nanocarriers | 2 |
| 13 | Smart/stimuli-responsive materials | 2 |
| 14 | Nanotoxicity, safety protocols, sustainability | 2 |
| 15 | Case studies: soft electronics, sensors, soft robots | 2 |
| | **Total** | **30** |

**Text Book:**

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

**Reference Books:**

| Title | Author(s) | Publication |
|---|---|---|

| | | |
|---|---|---|
| Introduction to Soft Matter: Synthetic and Biological Self-Assembling Materials | Ian W. Hamley | Wiley (2007) |
| Principles of Colloid and Surface Chemistry | Paul C. Hiemenz, Raj Rajagopalan | CRC Press (1997) |
| Nanostructured Soft Matter: Experiment, Theory, Simulation and Modeling | A. V. Zvelindovsky | Springer (2007) |

**Course Evaluation:**

**Theory:**

- Continuous Evaluation consists of two tests, each of 30 marks with a duration of 1 hour.
- Faculty Evaluation consists of 10 marks, as per the guidelines provided by the Course Coordinator.
- End Semester Examination will consist of a comprehensive 60 marks theory exam.

**Tutorials:**

- Continuous Evaluation consists of the performance in tutorials, which should be evaluated out of 10 marks for each tutorial in the next session. The average of these will be converted to 10 marks.
- Internal Viva component of 10 marks based on tutorial understanding and application.
- Tutorial-based assignment/quiz/problem-solving test of 20 marks during the End Semester Evaluation.
- Viva/Oral performance during the End Semester Evaluation carrying 10 marks.

**Course Outcome(s):**

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

| SECH7610 | Soft Nano Technology |
|---|---|
| CO 1 | Explain the fundamental physics, chemistry, and behavior of soft nanomaterials and soft matter systems. |
| CO 2 | Analyze intermolecular interactions and self-assembly mechanisms governing nanoscale behaviour. |
| CO 3 | Apply fabrication and processing techniques for developing functional soft nanostructures. |
| CO 4 | Select and use appropriate characterization tools for analyzing structural, mechanical, and dynamic properties of soft nanomaterials. |
| CO 5 | Evaluate applications, sustainability, environmental impact, and emerging technologies in soft nanotechnology. |

**Mapping of CO with PO**

| SECH7610 | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CO 1 | 3 | 2 | | 2 | | | | | | | |
| CO 2 | 2 | 3 | | 3 | 2 | | | | | | |
| CO 3 | 2 | 3 | 3 | 3 | 3 | | | | | | |

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

**Mapping of CO with PSO**

| **SECH7610** | PSO1 | PSO2 | PSO3 |
|---|---|---|---|
| CO 1 | 2 | 2 | 1 |
| CO 2 | 3 | 2 | 2 |
| CO 3 | 3 | 3 | 2 |
| CO 4 | 2 | 3 | 2 |
| CO 5 | 1 | 2 | 3 |

Level of Bloom's Revised Bloom's Taxonomy in Assessment

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

| **Module No** | **Content** | **RBT Level** |
|---|---|---|
| 01 | Introduction to Soft Nanotechnology and Soft Matter Systems | 3,5 |
| 02 | Intermolecular Interactions & Self-Assembly Mechanisms | 1,4 |
| 03 | Soft Nanomaterials Fabrication & Processing Techniques | 1,3 |
| 04 | Characterization Techniques for Soft Nanomaterials | 2,6 |
| 05 | Soft Nanotechnology in Biological & Biomedical Systems | 1,5 |
| 06 | Applications, Nanotoxicity, Sustainability & Emerging Trends | 3,4 |
| 07 | Soft Nano rheology, Dynamics & Transport Phenomena | 2,4 |
| 08 | Computational Modeling, Simulation & Industrial Applications of Soft Nanotechnology | 3,4 |

**P P Savani University**
**School of Engineering**

## Department of Chemical Engineering

Course Code: SECH7620
Course Name: Characterization Of Polymers, Elastomers And Composites
Prerequisite Course(s): -

**Teaching & Examination Scheme**

| Teaching Scheme (Hours/Week) | | | | Examination Scheme (Marks) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Theory | Practical | Tutorial | Credit | Theory | | Practical | | Tutorial | | Total |
| | | | | CE | ESE | CE | ESE | CE | ESE | |
| 3 | - | 2 | 5 | 40 | 60 | 0 | 0 | 40 | 60 | 200 |

CE: Continuous Evaluation, ESE: End Semester Exam

**Objective(s) of the course:**

- To provide a detailed understanding of structural, thermal, mechanical, and morphological characterization techniques used for polymers, elastomers, and composites.
- To train students in interpreting polymer characterization data for determining material properties, performance, and processing behavior.
- To develop analytical skills for evaluating polymer molecular weight, viscoelasticity, thermal transitions, crystallinity, and degradation behavior.
- To familiarize students with advanced instrumentation such as DSC, TGA, DMA, FTIR, SEM, TEM, XRD, GPC, Rheometers, and mechanical testers.
- To enable students to select appropriate characterization methods for industrial applications including packaging, automotive, biomedical, aerospace, and elastomer-based systems.

**Course Content:**

| Module | Content | Hour | Weightage In % |
|---|---|---|---|
| 1 | **Introduction to Polymer Characterization** Polymer structure, molecular architecture, copolymers, homopolymers, polymer chains, amorphous vs crystalline polymers, Tg, Tm, viscoelasticity, polymer phase behavior, physical aging, polymer testing standards, ASTM/ISO methods, NPTEL polymer characterization overview, sample preparation, polymer purity analysis, quality control methods. | 5 | 10 |
| 2 | **Molecular Characterization Techniques** Gel Permeation Chromatography (GPC), molecular weight distribution, Mn, Mw, Mz, polydispersity index (PDI), intrinsic viscosity, dilute solution viscometry, Mark-Houwink constants, osmometry, static light scattering, dynamic light scattering (DLS), MALDI-TOF, NMR spectroscopy, FTIR interpretation, functional group identification. | 7 | 20 |
| 3 | **Thermal Characterization of Polymers** Differential Scanning Calorimetry (DSC), Thermogravimetric Analysis (TGA), Differential Thermal Analysis (DTA), | 5 | 10 |

| | | | |
|---|---|---|---|
| | thermograms, heat of fusion, crystallinity %, oxidative stability, thermal degradation, TGA kinetics, thermomechanical analysis (TMA), melting transitions, glass transition, thermal stability index, thermograms interpretation, NPTEL polymer thermal analysis. | | |
| 4 | **Mechanical and Rheological Characterization** Tensile testing, elongation at break, modulus, impact strength, hardness (Shore A/D), DMA (Dynamic Mechanical Analysis), storage modulus, loss modulus, tan delta, stress relaxation, creep analysis, viscoelasticity, oscillatory shear, rheometry, flow curves, melt flow index (MFI), fracture toughness. | 5 | 10 |
| 5 | **Morphological and Structural Characterization** Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), X-ray Diffraction (XRD), Wide Angle XRD, SAXS (Small Angle X-ray Scattering), optical microscopy, polarized light microscopy, crystalline lamellae, spherulites, phase separation, microphase morphology, filler dispersion, interface analysis, composite microstructure, nanocomposites. | 5 | 10 |
| 6 | **Characterization of Elastomers** Rubber elasticity, crosslink density, vulcanization analysis, Mooney viscosity, stress–strain behavior of elastomers, rebound resilience, abrasion resistance, fatigue testing, cure curves, rheometry for rubber, dynamic fatigue, swelling behavior, hardness testing, hysteresis, elastomer blend characterization, thermal aging. | 8 | 20 |
| 7 | **Characterization of Polymer Composites** Fiber-reinforced composites, matrix–filler interaction, fiber orientation, interfacial bonding, void content, mechanical testing of composites, flexural strength, interlaminar shear strength, impact characterization, thermal expansion mismatch, failure modes, microcrack analysis, fiber pull-out, fracture surface morphology, rule of mixtures. | 5 | 10 |
| 8 | **Case Studies & Industry Applications** Packaging polymers, automotive polymers, aerospace composites, biomedical polymers, rubber industry testing, polymer degradation, recyclability analysis, sustainability metrics, additive effects, stabilizers, fillers, nanocomposites, failure case studies, environmental stress cracking, industrial quality control, NPTEL applications case studies. | 5 | 10 |
| | **Total** | **45** | **100** |

**Tutorials**

| Tutorial | Content | Duration (Hours) |
|---|---|---|
| 1 | Introduction to polymer structure and need for characterization | 1 |
| 2 | Sample preparation and conditioning methods | 1 |
| 3 | Molecular weight analysis using GPC and viscometry | 2 |
| 4 | FTIR and NMR interpretation for common polymers | 2 |

| | | |
|---|---|---|
| 5 | DSC thermogram interpretation and crystallinity calculation | 2 |
| 6 | TGA decomposition kinetics and thermal stability | 2 |
| 7 | DMA modulus interpretation and viscoelastic analysis | 2 |
| 8 | Rheology: MFI, viscosity curves, oscillatory shear | 2 |
| 9 | SEM sample preparation and microstructure identification | 2 |
| 10 | XRD pattern analysis and crystallinity estimation | 2 |
| 11 | Elastomer testing: Mooney viscosity, cure curves | 2 |
| 12 | Composite mechanical testing and failure analysis | 2 |
| 13 | Case studies of polymer degradation and recycling | 2 |
| 14 | Industrial QC methods for polymers and composites | 2 |
| 15 | Instrumentation selection for real-world applications | 2 |

**Text Book:**

| Title | Author(s) | Publication |
|---|---|---|
| Polymer Science and Technology | Joel R. Fried | Prentice Hall |

**Reference Books:**

| Title | Author(s) | Publication |
|---|---|---|
| Polymer Characterization: Physical Techniques | D. Campbell & J.R. White | CRC Press |
| Composite Materials: Science and Engineering | K.K. Chawla | Springer |
| Principles of Polymer Engineering | R.J. Young & P.A. Lovell | Elsevier |

**Course Evaluation:**

**Theory:**

- Continuous Evaluation consists of two tests, each of 30 marks with a duration of 1 hour.
- Faculty Evaluation consists of 10 marks, as per the guidelines provided by the Course Coordinator.
- End Semester Examination will consist of a comprehensive 60 marks theory exam.

**Tutorials:**

- Continuous Evaluation consists of the performance in tutorials, which should be evaluated out of 10 marks for each tutorial in the next session. The average of these will be converted to 10 marks.
- Internal Viva component of 10 marks based on tutorial understanding and application.
- Tutorial-based assignment/quiz/problem-solving test of 20 marks during the End Semester Evaluation.
- Viva/Oral performance during the End Semester Evaluation carrying 10 marks.

**Course Outcome(s):**

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

| SECH7620 | Characterization Of Polymers, Elastomers And Composites |
|---|---|
| CO 1 | Explain fundamental characterization techniques and select appropriate methods for polymer, elastomer, and composite analysis. |
| CO 2 | Interpret molecular weight, thermal, mechanical, and rheological data to evaluate polymer performance. |
| CO 3 | Analyze microstructure and morphology using SEM, TEM, XRD, and optical microscopy. |
| CO 4 | Perform characterization of elastomers and composites and interpret advanced material behavior. |
| CO 5 | Apply characterization data for industrial quality control, failure diagnosis, and materials development. |

**Mapping of CO with PO**

| SECH7620 | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CO 1 | 3 | 2 | | 2 | | | | | | | |
| CO 2 | 2 | 3 | | 3 | 2 | | | | | | |
| CO 3 | 2 | 3 | 3 | 3 | 3 | | | | | | |
| CO 4 | 1 | 2 | 3 | 2 | 2 | | | | | 2 | |
| CO 5 | | | | | | | | 3 | 3 | 3 | 2 |

**Mapping of CO with PSO**

| SECH7620 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|
| CO 1 | 2 | 2 | 1 |
| CO 2 | 3 | 2 | 2 |
| CO 3 | 3 | 3 | 2 |
| CO 4 | 2 | 3 | 2 |
| CO 5 | 1 | 2 | 3 |

Level of Bloom's Revised Bloom's Taxonomy in Assessment

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

| Module No | Content | RBT Level |
|---|---|---|
| 01 | Introduction to Polymer Characterization | 3,5 |
| 02 | Molecular Characterization Techniques | 1,4 |
| 03 | Thermal Characterization of Polymers | 1,3 |
| 04 | Mechanical and Rheological Characterization | 2,6 |
| 05 | Morphological and Structural Characterization | 1,5 |
| 06 | Characterization of Elastomers | 3,4 |
| 07 | Characterization of Polymer Composites | 2,4 |
| 08 | Case Studies & Industry Applications | 3,4 |

# SECOND YEAR

# SCHOOL OF. ENGINEERING

| P P SAVANI UNIVERSITY | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SCHOOL OF ENGINEERING | | | | | | | | | | | | | | | | | |
| TEACHING & EXAMINATION SCHEME FOR M. TECH. (RESEARCH) IN CHEMICAL ENGINEERING AY: 2025-26 | | | | | | | | | | | | | | | | | |
| Sem | Course Code | Course Title | Course Category | Offered By | Teaching Scheme | | | | | Examination Scheme | | | | | | | |
| | | | | | Contact Hours | | | | Credit | Theory | | Practical | | Tutorial | | Total |
| | | | | | Theory | Practical | Tutorial | Total | | CE | ESE | CE | ESE | CE | ESE | |
| 3 | SECH8010 | Scientific Communication | Major/Core | CH | 3 | 0 | 2 | 5 | 5 | 40 | 60 | 0 | 0 | 40 | 60 | 200 |
| | SECH8910 | Research Project-III | RP/OJT | CH | 0 | 10 | 0 | 10 | 10 | 0 | 0 | 80 | 120 | 0 | 0 | 200 |
| | | Elective Course-V | Minor | CH | 3 | 0 | 2 | 5 | 5 | 40 | 60 | 0 | 0 | 40 | 60 | 200 |
| | | Elective Course-VI | Minor | CH | 3 | 0 | 2 | 5 | 5 | 40 | 60 | 0 | 0 | 40 | 60 | 200 |
| | | | | | | | **Total** | **25** | **25** | | | | | | | **800** |
| 4 | SECH8920 | Major Research Project | RP/OJT | CH | 0 | 25 | 0 | 25 | 25 | 0 | 0 | 200 | 300 | 0 | 0 | 500 |
| | | | | | | | **Total** | **25** | **25** | | | | | | | **500** |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Elective Courses | | | | | | | | | | | | | |
| **3** | SECH8510 | Polymers: Concepts, Properties, Uses And Sustainability | Minor | CH | 3 | 0 | 2 | 5 | 5 | 40 | 60 | 0 | 0 | 40 | 60 | 200 |
| **3** | SECH8520 | Membrane Technology | Minor | CH | 3 | 0 | 2 | 5 | 5 | 40 | 60 | 0 | 0 | 40 | 60 | 200 |
| **3** | SECH8530 | Introduction To Colloid And Interface Science And Engineering | Minor | CH | 3 | 0 | 2 | 5 | 5 | 40 | 60 | 0 | 0 | 40 | 60 | 200 |
| **3** | SECH8540 | Mathematical Modelling And Simulation Of Chemical Engineering Process | Minor | CH | 3 | 0 | 2 | 5 | 5 | 40 | 60 | 0 | 0 | 40 | 60 | 200 |
| **3** | SECH8550 | Chemical Process Safety | Minor | CH | 3 | 0 | 2 | 5 | 5 | 40 | 60 | 0 | 0 | 40 | 60 | 200 |
| **3** | SECH8560 | Corrosion/Environmental Degradation/Surface Engineering | Minor | CH | 3 | 0 | 2 | 5 | 5 | 40 | 60 | 0 | 0 | 40 | 60 | 200 |

**P P Savani University**
**School of Engineering**

## Department of Chemical Engineering

Course Code: SECH8010
Course Name: Scientific Communication
Prerequisite Course(s): -

**Teaching & Examination Scheme**

| Teaching Scheme (Hours/Week) | | | | Examination Scheme (Marks) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Theory | Practical | Tutorial | Credit | Theory | | Practical | | Tutorial | | Total |
| | | | | CE | ESE | CE | ESE | CE | ESE | |
| 3 | 0 | 2 | 5 | 40 | 60 | 0 | 0 | 40 | 60 | 200 |

CE: Continuous Evaluation, ESE: End Semester Exam

**Objective(s) of the course:**

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

**Course Content:**

| Module | Content | Hour | Weightage In % |
|---|---|---|---|
| 1. | **Fundamentals of Scientific Communication** Importance of scientific communication in research and academia, Types: Written, oral, visual, and digital communication, Principles of clarity, accuracy, brevity, and objectivity, Audience analysis and purpose-driven writing | 5 | 10 |
| 2. | **Technical Writing and Documentation** Structure and components of technical reports, project reports, and research papers, Style guides: IEEE, APA, Chicago, ACS formats, Writing abstracts, summaries, introductions, and conclusions, Common grammar and language issues in technical writing | 7 | 20 |
| 3. | **Scientific Publishing and Peer Review** Types of scientific publications: Journals, conferences, books, patents, Selecting appropriate journals (impact factor, | 5 | 10 |

| | | | |
|---|---|---|---|
| | indexing, scope), Manuscript submission process and peer review system, Predatory journals and publication ethics | | |
| 4. | **Research Proposal and Grant Writing**<br>Structure of research proposals, Writing research objectives, methodology, expected outcomes, Budget preparation, timelines, deliverables, Overview of funding agencies: DST, CSIR, DBT, UGC, SERB, and international agencies | 5 | 10 |
| 5. | **Oral and Visual Scientific Communication**<br>Planning and delivering effective research presentations, Slide preparation and visual design principles, Scientific posters: design and layout, Handling questions and feedback during conferences | 5 | 10 |
| 6. | **Communication for Patents, Standards, and Technical Manuals**<br>Writing invention disclosure forms and patent summaries, Writing for SOPs, user manuals, and technical documentation, Terminology management and readability improvement, Collaborative writing and version control | 8 | 20 |
| 7. | **Digital and Online Scientific Communication**<br>Science blogs, podcasts, and social media in research dissemination, Creating and managing professional research profiles (ORCID, ResearchGate, Google Scholar), Open Access vs. Subscription publishing, Science communication for public outreach | 5 | 10 |
| 8. | **Ethics and Professionalism in Scientific Communication**<br>Plagiarism, self-plagiarism, and citation ethics, Authorship criteria and conflicts, Data sharing and reproducibility, Gender-neutral and inclusive language in research writing | 5 | 10 |
| | **Total** | **45** | **100** |

**List of Tutorials**

| Tutorial | Content | Duration (Hours) |
|---|---|---|
| 1 | Fundamentals of Scientific Communication | 2 |
| 2 | Technical Writing and Documentation | 2 |
| 3 | Polishing Abstracts and Summaries | 2 |
| 4 | Scientific Publishing and Peer Review | 2 |
| 5 | Understanding Peer Review Processes | 2 |
| 6 | Research Proposal and Grant Writing | 2 |
| 7 | Preparing a Grant Budget and Timeline | 2 |
| 8 | Oral and Visual Scientific Communication | 2 |
| 9 | Creating a Scientific Poster | 2 |
| 10 | Practicing Presentation Q&A | 2 |
| 11 | Communication for Patents, Standards, and Technical Manuals | 2 |
| 12 | Digital and Online Scientific Communication | 2 |
| 13 | Building a Research Profile | 2 |
| 14 | Ethics and Professional plinary Communication | 2 |
| 15 | Ethics and Professionalism in Scientific Communication | 2 |
| | **Total** | **30** |

**Text Book:**

| Title | Author(s) | Publication |
|---|---|---|

| | | |
|---|---|---|
| Scientific Writing and Communication: Papers, Proposals, and Presentations | Angelika H. Hofmann | Oxford University Press |

**Reference Books:**

| Title | Author(s) | Publication |
|---|---|---|
| The Craft of Scientific Writing | Michael Alley | Springer |
| Writing Science: How to Write Papers That Get Cited and Proposals That Get Funded | Joshua Schimel | Oxford University Press |

**Course Evaluation:**

**Theory:**

- Continuous Evaluation consists of two tests, each of 30 marks with a duration of 1 hour.
- Faculty Evaluation consists of 10 marks, as per the guidelines provided by the Course Coordinator.
- End Semester Examination will consist of a comprehensive 60 marks theory exam.

**Tutorials:**

- Continuous Evaluation consists of the performance in tutorials, which should be evaluated out of 10 marks for each tutorial in the next session. The average of these will be converted to 10 marks.
- Internal Viva component of 10 marks based on tutorial understanding and application.
- Tutorial-based assignment/quiz/problem-solving test of 20 marks during the End Semester Evaluation.
- Viva/Oral performance during the End Semester Evaluation carrying 10 marks.

**Course Outcome(s):**

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

| SECH8010 | Scientific Communication |
|---|---|
| CO 1 | Demonstrate understanding of different forms of scientific communication |
| CO 2 | Develop structured technical documents such as reports, research papers, and grant proposals using standard writing styles. |
| CO 3 | Navigate the publication process and evaluate journals for scientific dissemination while avoiding unethical practices. |
| CO 4 | Plan and deliver effective scientific presentations, posters, and digital content for academic and public engagement. |
| CO 5 | Apply ethical standards, responsible authorship practices, and digital tools for transparent, inclusive, and professional scientific communication. |

**Mapping of CO with PO**

| SECH8010 | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CO 1 | 1 | 1 | | | | | | | 2 | | 2 |
| CO 2 | 1 | 2 | | 1 | 1 | | | | 3 | | 2 |
| CO 3 | 1 | 2 | | 2 | 1 | | 3 | | 2 | | 2 |

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

**Mapping of CO with PSO**

| **SECH8010** | PSO1 | PSO2 | PSO3 |
|---|---|---|---|
| CO 1 | 1 | 3 | 1 |
| CO 2 | 2 | 3 | 2 |
| CO 3 | 1 | 2 | 3 |
| CO 4 | 1 | 3 | 2 |
| C0 5 | 1 | 2 | 3 |

Level of Bloom's Revised Bloom's Taxonomy in Assessment

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

| **Module No** | **Content** | **RBT Level** |
|---|---|---|
| 01 | Fundamentals of Scientific Communication | 3,5 |
| 02 | Technical Writing and Documentation | 1,4 |
| 03 | Scientific Publishing and Peer Review | 1,3 |
| 04 | Research Proposal and Grant Writing | 2,6 |
| 05 | Oral and Visual Scientific Communication | 1,5 |
| 06 | Communication for Patents, Standards, and Technical Manuals | 3,4 |
| 07 | Digital and Online Scientific Communication | 2,4 |
| 08 | Ethics and Professionalism in Scientific Communication | 3,4 |

## P P Savani University
## School of Engineering
## Department of Chemical Engineering

Course Code: SECH8510
Course Name: Polymers: Concepts, Properties, Uses And Sustainability
Prerequisite Course(s): -

**Teaching & Examination Scheme**

| Teaching Scheme (Hours/Week) | | | | Examination Scheme (Marks) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Theory | Practical | Tutorial | Credit | Theory | | Practical | | Tutorial | | Total |
| | | | | CE | ESE | CE | ESE | CE | ESE | |
| 3 | - | 2 | 5 | 40 | 60 | 0 | 0 | 40 | 60 | 200 |

CE: Continuous Evaluation, ESE: End Semester Exam

**Objective(s) of the course:**

- To introduce the fundamental concepts of polymer chemistry, structure, classification, and molecular architecture.
- To provide a detailed understanding of polymer properties including thermal, mechanical, rheological, and morphological behavior.
- To familiarize students with polymer synthesis routes, processing techniques, and industrial polymer applications.
- To highlight sustainability aspects, biodegradable polymers, recycling technologies, and environmental impact assessment.
- To build analytical, characterization, and problem-solving skills relevant to polymer engineering and green materials.

**Course Content:**

| Module | Content | Hour | Weightage In % |
|---|---|---|---|
| 1 | **Introduction to Polymer Science**<br>Monomers, polymers, degree of polymerization, molecular weight distribution, step-growth polymerization, chain-growth polymerization, copolymers, polymer architecture, crystallinity, amorphous polymers, Tg (glass transition temperature), Tm (melting temperature), tacticity, polymer nomenclature, polymerization kinetics, stereoregularity, polymer microstructure. | 5 | 10 |
| 2 | **Polymer Properties and Characterization**<br>Rheology, viscoelasticity, crystallinity, mechanical properties, tensile strength, modulus, elongation at break, thermal behavior, DSC (Differential Scanning Calorimetry), TGA (Thermogravimetric Analysis), DMA (Dynamic Mechanical Analysis), GPC (Gel Permeation Chromatography), FTIR, NMR, XRD, morphology, polymer-solvent interactions, Flory–Huggins parameter. | 7 | 20 |
| 3 | **Polymer Processing Techniques** | 5 | 10 |

| | | | |
|---|---|---|---|
| | Extrusion, injection molding, blow molding, compression molding, rotational molding, calendaring, thermoforming, fiber spinning, film blowing, pelletizing, compounding, extrusion dies, screw design, plasticization, rheological flow, melt processing, shear thinning. | | |
| 4 | **Industrial Polymers and Applications**<br>Polyethylene, polypropylene, PVC, PET, PS, nylons, polyurethanes, elastomers, adhesives, coatings, composites, engineering plastics, thermosets, thermoplastics, packaging materials, automotive polymers, biomedical polymers, conductive polymers. | 5 | 10 |
| 5 | **Biopolymers, Degradation, and Sustainability**<br>Biodegradable polymers, polylactic acid (PLA), cellulose derivatives, starch-based polymers, green chemistry, life cycle assessment (LCA), recycling (mechanical/chemical), microplastics, environmental impact, circular economy, compostability, polymer degradation, oxidation, hydrolysis, photodegradation, waste valorization, sustainable materials. | 5 | 10 |
| 6 | **Advanced and Smart Polymers**<br>Stimuli-responsive polymers, nanocomposites, polymer blends, hydrogels, shape-memory polymers, self-healing polymers, conductive polymers, biomedical polymers, drug-delivery systems, high-performance polymers, barrier properties, flame retardants, membrane polymers, supramolecular polymers, polymer nanotechnology. | 8 | 20 |
| 7 | **Polymer Recycling, Circular Economy, and Waste Management**<br>Polymer waste generation and classification, sources of plastic waste, challenges in polymer recycling, mechanical recycling processes, chemical recycling techniques, energy recovery, upcycling and downcycling concepts, circular economy principles in polymers, design for recyclability, waste management strategies, regulatory aspects, case studies on polymer recycling industries, role of polymers in sustainable development. | 5 | 10 |
| 8 | **Polymer Composites, Nanotechnology, and Emerging Applications**<br>Polymer composites classification, fiber-reinforced polymers, matrix materials, fillers and reinforcements, polymer nanocomposites, dispersion techniques, interfacial interactions, structure–property relationships, barrier and mechanical enhancement, applications in automotive, aerospace, biomedical and packaging sectors, emerging polymer technologies, future trends in polymer engineering. | 5 | 10 |
| | **Total** | **45** | **100** |

**Tutorials**

| **Tutorial** | **Content** | **Duration (Hours)** |
|---|---|---|
| 1 | Basic polymer definitions, monomers, polymer classification | 1 |
| 2 | Molecular weight distribution and calculations (Mn, Mw, PDI) | 1 |

| | | |
|---|---|---|
| 3 | Step-growth vs. chain-growth polymerization mechanisms | 2 |
| 4 | Polymer microstructures, tacticity, crystallinity | 2 |
| 5 | Mechanical properties and viscoelastic behavior | 2 |
| 6 | Thermal analysis techniques (DSC, TGA, DMA) | 2 |
| 7 | Spectroscopic characterization (FTIR, NMR, XRD) | 2 |
| 8 | Polymer processing flow behavior and rheology | 2 |
| 9 | Injection molding and extrusion calculations | 2 |
| 10 | Industrial polymers case study (LDPE, PET, Nylon) | 2 |
| 11 | Composite polymer systems and applications | 2 |
| 12 | Biodegradable polymers and degradation pathways | 2 |
| 13 | Recycling technologies (mechanical, chemical) | 2 |
| 14 | Life cycle assessment (LCA) exercises | 2 |
| 15 | Smart polymers and advanced applications (case study) | 2 |

**Text Book:**

| Title | Author(s) | Publication |
|---|---|---|
| Polymer Science and Technology | Joel R. Fried | Prentice Hall |

**Reference Books:**

| Title | Author(s) | Publication |
|---|---|---|
| Introduction to Polymers | R.J. Young, P.A. Lovell | CRC Press |
| Polymer Chemistry | Malcolm P. Stevens | Oxford University Press |
| Principles of Polymer Engineering | N.G. McCrum, C.P. Buckley, C.B. Bucknall | Oxford Science Publications |

**Course Evaluation:**

**Theory:**

- Continuous Evaluation consists of two tests, each of 30 marks with a duration of 1 hour.
- Faculty Evaluation consists of 10 marks, as per the guidelines provided by the Course Coordinator.
- End Semester Examination will consist of a comprehensive 60 marks theory exam.

**Tutorials:**

- Continuous Evaluation consists of the performance in tutorials, which should be evaluated out of 10 marks for each tutorial in the next session. The average of these will be converted to 10 marks.
- Internal Viva component of 10 marks based on tutorial understanding and application.
- Tutorial-based assignment/quiz/problem-solving test of 20 marks during the End Semester Evaluation.
- Viva/Oral performance during the End Semester Evaluation carrying 10 marks.

**Course Outcome(s):**

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

| SECH8510 | Polymers: Concepts, Properties, Uses And Sustainability |
|---|---|

| | |
|---|---|
| CO 1 | Explain the fundamentals of polymer chemistry, structural features, and classification of polymers. |
| CO 2 | Analyze polymer properties and interpret data obtained from thermal, mechanical, and spectroscopic characterization techniques. |
| CO 3 | Evaluate polymer processing methods and correlate processing parameters with material properties. |
| CO 4 | Identify industrially important polymers and justify their applications in various sectors. |
| CO 5 | Assess biopolymers, sustainability strategies, degradation mechanisms, and environmentally responsible polymer technologies. |

**Mapping of CO with PO**

| SECH8510 | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CO 1 | 3 | 2 | | 2 | | | | | | | |
| CO 2 | 2 | 3 | | 3 | 2 | | | | | | |
| CO 3 | 2 | 3 | 3 | 3 | 3 | | | | | | |
| CO 4 | 1 | 2 | 3 | 2 | 2 | | | | | 2 | |
| CO 5 | | | | | | | | 3 | 3 | 3 | 2 |

**Mapping of CO with PSO**

| SECH8510 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|
| CO 1 | 2 | 2 | 1 |
| CO 2 | 3 | 2 | 2 |
| CO 3 | 3 | 3 | 2 |
| CO 4 | 2 | 3 | 2 |
| CO 5 | 1 | 2 | 3 |

Level of Bloom's Revised Bloom's Taxonomy in Assessment

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

| Module No | Content | RBT Level |
|---|---|---|
| 01 | Introduction to Polymer Science | 3,5 |
| 02 | Polymer Properties and Characterization | 1,4 |
| 03 | Polymer Processing Techniques | 1,3 |
| 04 | Industrial Polymers and Applications | 2,6 |
| 05 | Biopolymers, Degradation, and Sustainability | 1,5 |
| 06 | Advanced and Smart Polymers | 3,4 |
| 07 | Polymer Recycling, Circular Economy, and Waste Management | 2,4 |
| 08 | Polymer Composites, Nanotechnology, and Emerging Applications | 3,4 |

# P P Savani University
## School of Engineering
## Department of Chemical Engineering

Course Code: SECH8910
Course Name: Research Project-III
Prerequisite Course/s: -

**Teaching & Examination Scheme:**

| Teaching Scheme (Hours/Week) | | | | Examination Scheme (Marks) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Theory | Practical | Tutorial | Credit | Theory | | Practical | | Tutorial | | Total |
| | | | | CE | ESE | CE | ESE | CE | ESE | |
| - | 10 | - | 10 | - | - | 80 | 120 | - | - | 200 |

CE: Continuous Evaluation, ESE: End Semester Exam

**Objective(s) of the course:**

To help learners to

- To engage students in identifying, formulating, and solving real-world research problems.
- To encourage independent and original thinking in designing, implementing, and evaluating computational methods.
- To promote the use of research methodology, scientific writing, and effective communication of results.

**List of Practical's:**

| Sr. No. | Name of Practical | Hours |
|---|---|---|
| 1. | Orientation, topic finalization, and problem statement definition. | 10 |
| 2. | Literature review using IEEE/ACM/ScienceDirect databases. | 20 |
| 3 | Identification of research gap and formulation of research objectives. | 10 |
| 4 | Selection of methodology, tools, and technologies. | 10 |
| 5 | Initial prototype design or dataset collection/preprocessing. | 10 |
| 6 | Core development: algorithm/model/system design begins. | 10 |
| 7 | Implementation continues with performance testing. | 30 |
| 8 | Experimentation, result collection, tuning. | 20 |
| 9 | Result validation (graphs, statistical methods, comparisons). | 20 |
| 10 | Drafting research report/paper, presentation preparation | 10 |
| | **TOTAL** | **150** |

**Practical:**

- Each student should be assigned a faculty guide.
- Regular weekly review meetings are mandatory.
- Mid-term internal evaluation and final external viva should be scheduled.
- Research should ideally be aligned with current thrust areas: chemical engineering, material science etc.

**Course Outcome(s):**

After the completion of the course, the student will be able to

| SECH8910 | Research Project-III |
|---|---|
| CO1 | Identify and define a research problem with reference to current trends in Chemical Engineering. |
| CO2 | Analyze relevant literature and select appropriate tools and techniques. |
| CO3 | Develop and implement innovative solutions or models for real-world problems. |
| CO4 | Evaluate research findings and present technical documentation and publications. |
| CO 5 | Exhibit professional ethics, teamwork, and project management skills in executing a research project. |

**Mapping of CO with PO**

| SECH8910 | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CO 1 | 3 | 2 | | 2 | | | | | | | |
| CO 2 | 2 | 3 | | 3 | 2 | | | | | | |
| CO 3 | 2 | 3 | 3 | 3 | 3 | | | | | | |
| CO 4 | 1 | 2 | 3 | 2 | 2 | | | | | 2 | |
| CO 5 | | | | | | | | 3 | 3 | 3 | 2 |

**Mapping of CO with PSO**

| SECH8910 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|
| CO 1 | 2 | 2 | 1 |
| CO 2 | 3 | 2 | 2 |
| CO 3 | 3 | 3 | 2 |
| CO 4 | 2 | 3 | 2 |
| CO 5 | 1 | 2 | 3 |

**P P Savani University**
**School of Engineering**

**Department of Chemical Engineering**

Course Code: SECH8520
Course Name: Membrane Technology
Prerequisite Course(s): -

**Teaching & Examination Scheme**

| Teaching Scheme (Hours/Week) | | | | Examination Scheme (Marks) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Theory | Practical | Tutorial | Credit | Theory | | Practical | | Tutorial | | Total |
| | | | | CE | ESE | CE | ESE | CE | ESE | |
| 3 | - | 2 | 5 | 40 | 60 | 0 | 0 | 40 | 60 | 200 |

CE: Continuous Evaluation, ESE: End Semester Exam

**Objective(s) of the course:**

- To provide comprehensive knowledge of membrane science, classification, and transport mechanisms for separation processes.
- To develop an understanding of membrane materials, fabrication techniques, and performance characteristics.
- To familiarize students with pressure-driven, concentration-driven, electrically driven, and temperature-driven membrane processes.
- To enable students to design, model, and analyze membrane modules and evaluate fouling, scaling, and cleaning strategies.
- To expose students to industrial applications of membrane technology in water treatment, biotechnology, petrochemicals, pharmaceuticals, and environmental engineering.

**Course Content:**

| Module | Content | Hour | Weightage In % |
|---|---|---|---|
| 1 | **Introduction to Membrane Science and Engineering** membrane science, membrane engineering, classification of membranes, symmetric membranes, asymmetric membranes, dense membranes, porous membranes, polymeric membranes, inorganic membranes, mixed-matrix membranes, biomimetic membranes, membrane morphology, membrane performance, selectivity, permeability, permselectivity, driving forces, separation mechanisms. | 5 | 10 |
| 2 | **Membrane Materials and Fabrication Techniques** polymeric materials, inorganic membranes, ceramics, metals, glass, composite membranes, thin-film composite (TFC), hollow fiber fabrication, phase inversion, interfacial polymerization, sol–gel method, track-etched membranes, electrospinning, membrane casting, surface modification, functionalization, pore formation mechanisms. | 7 | 20 |
| 3 | **Transport Phenomena in Membrane Systems** | 5 | 10 |

| | | | |
|---|---|---|---|
| | solution–diffusion model, pore flow model, Hagen–Poiseuille flow, concentration polarization, osmotic pressure, flux equations, mass transfer resistance, boundary layer effects, diffusion coefficients, Knudsen diffusion, electrochemical gradients, solvent transport, solute transport, membrane permeability, diffusion–convection interactions. | | |
| 4 | **Pressure-Driven Membrane Processes**<br>microfiltration (MF), ultrafiltration (UF), nanofiltration (NF), reverse osmosis (RO), transmembrane pressure, membrane modules, spiral-wound modules, hollow fiber modules, tubular modules, flux decline, fouling, cake formation, pore blocking, pretreatment methods, permeate recovery, rejection characteristics. | 5 | 10 |
| 5 | **Concentration-, Electrical-, and Temperature-Driven Membrane Processes**<br><br>dialysis, electrodialysis (ED), electrodeionization (EDI), pervaporation, vapor permeation, membrane distillation (MD), thermal gradients, ion-exchange membranes, permselectivity, current efficiency, mass transport, membrane stack, desalination, dehydration, organic solvent separations, conductivity. | 5 | 10 |
| 6 | **Membrane Fouling, Scaling, Cleaning, and Module Design**<br>fouling mechanisms, pore constriction, adsorption, biofouling control, scaling, antiscalants, chemical cleaning, backwashing, air sparging, module configuration, design equations, flow distribution, polarization layer control, membrane life, operational optimization, performance monitoring, maintenance strategies. | 8 | 20 |
| 7 | **Industrial Applications of Membrane Technology**<br>water purification, desalination, industrial wastewater treatment, biotechnology, pharmaceutical separations, food processing, dairy membranes, bioreactors (MBR), gas separation, hydrogen recovery, $CO_2$ capture, fuel cells, hemodialysis, petrochemical separations, solvent recovery. | 5 | 10 |
| 8 | **Advanced Membrane Technologies, Sustainability, and Emerging Trends**<br>Advanced membrane materials and next-generation membranes, nanocomposite and mixed-matrix membranes, graphene-based and carbon nanotube membranes, biomimetic and aquaporin membranes, smart and responsive membranes, membrane process intensification, hybrid membrane systems, energy-efficient membrane operations, sustainability in membrane technology, membrane recycling and reuse, life cycle assessment (LCA) of membrane systems, environmental impact, techno-economic considerations, future trends and research directions in membrane engineering. | 5 | 10 |
| | **Total** | **45** | **100** |

**Tutorials**

| Tutorial | Content | Duration (Hours) |
|---|---|---|
| 1 | Introduction to membrane types, classification, structure | 1 |
| 2 | Membrane materials—polymeric, ceramic, composite | 1 |
| 3 | Phase inversion method (calculation + demonstration) | 2 |
| 4 | Characterization techniques—porosity, zeta potential | 2 |
| 5 | Flux calculation using transport models | 2 |
| 6 | Concentration polarization & mass-transfer coefficient | 2 |
| 7 | MF/UF/NF/RO mechanism comparison & calculations | 2 |
| 8 | Electrodialysis & EDI system design basics | 2 |
| 9 | Pervaporation and MD membrane design | 2 |
| 10 | Gas separation membrane performance calculations | 2 |
| 11 | Fouling mechanisms & modelling | 2 |
| 12 | Cleaning strategies & membrane maintenance planning | 2 |
| 13 | Membrane module design—spiral, hollow fiber | 2 |
| 14 | Industrial case studies (Desalination, MBR, PV) | 2 |
| 15 | Simulation using simple membrane models in Excel/Python | 2 |

**Text Book:**

| Title | Author(s) | Publication |
|---|---|---|
| Membrane Technology and Applications | Richard W. Baker | John Wiley & Sons |

**Reference Books:**

| Title | Author(s) | Publication |
|---|---|---|
| Membrane Separation Processes | Kaushik Nath | PHI Learning |
| Principles of Membrane Technology | E. Drioli, L. Giorno | CRC Press |

**Course Evaluation:**

**Theory:**

- Continuous Evaluation consists of two tests, each of 30 marks with a duration of 1 hour.
- Faculty Evaluation consists of 10 marks, as per the guidelines provided by the Course Coordinator.
- End Semester Examination will consist of a comprehensive 60 marks theory exam.

**Tutorials:**

- Continuous Evaluation consists of the performance in tutorials, which should be evaluated out of 10 marks for each tutorial in the next session. The average of these will be converted to 10 marks.
- Internal Viva component of 10 marks based on tutorial understanding and application.
- Tutorial-based assignment/quiz/problem-solving test of 20 marks during the End Semester Evaluation.
- Viva/Oral performance during the End Semester Evaluation carrying 10 marks.

**Course Outcome(s):**

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

| SECH8520 | **Membrane Technology** |
|---|---|
| CO 1 | Understand membrane science, classification, morphology, and transport mechanisms. |
| CO 2 | Analyze membrane materials, fabrication processes, and characterization techniques. |
| CO 3 | Apply and evaluate pressure-driven, concentration-driven, and electrically driven membrane systems. |
| CO 4 | Identify fouling, scaling phenomena and propose effective cleaning and mitigation strategies. |
| CO 5 | Design membrane modules and evaluate industrial applications for water, gas, and biological separations. |

**Mapping of CO with PO**

| SECH8520 | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CO 1 | 3 | 2 | | 2 | | | | | | | |
| CO 2 | 2 | 3 | | 3 | 2 | | | | | | |
| CO 3 | 2 | 3 | 3 | 3 | 3 | | | | | | |
| CO 4 | 1 | 2 | 3 | 2 | 2 | | | | | 2 | |
| CO 5 | | | | | | | | 3 | 3 | 3 | 2 |

**Mapping of CO with PSO**

| SECH8520 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|
| CO 1 | 2 | 2 | 1 |
| CO 2 | 3 | 2 | 2 |
| CO 3 | 3 | 3 | 2 |
| CO 4 | 2 | 3 | 2 |
| CO 5 | 1 | 2 | 3 |

Level of Bloom's Revised Bloom's Taxonomy in Assessment

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

| Module No | Content | RBT Level |
|---|---|---|
| 01 | Introduction to Membrane Science and Engineering | 3,5 |
| 02 | Membrane Materials and Fabrication Techniques | 1,4 |
| 03 | Transport Phenomena in Membrane Systems | 1,3 |
| 04 | Pressure-Driven Membrane Processes | 2,6 |
| 05 | Concentration-, Electrical-, and Temperature-Driven Membrane Processes | 1,5 |
| 06 | Membrane Fouling, Scaling, Cleaning, and Module Design | 3,4 |
| 07 | Industrial Applications of Membrane Technology | 2,4 |

| | | |
|---|---|---|
| 08 | Advanced Membrane Technologies, Sustainability, and Emerging Trends | 3,4 |

## P P Savani University
## School of Engineering
## Department of Chemical Engineering

Course Code: SECH8530
Course Name: Introduction To Colloid And Interface Science And Engineering
Prerequisite Course(s): -

**Teaching & Examination Scheme**

| Teaching Scheme (Hours/Week) | | | | Examination Scheme (Marks) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Theory | Practical | Tutorial | Credit | Theory | | Practical | | Tutorial | | Total |
| | | | | CE | ESE | CE | ESE | CE | ESE | |
| 3 | - | 2 | 5 | 40 | 60 | 0 | 0 | 40 | 60 | 200 |

CE: Continuous Evaluation, ESE: End Semester Exam

**Objective(s) of the course:**

- To introduce the fundamental concepts of colloid and interface science applicable to chemical, materials, pharmaceutical, and environmental engineering.
- To understand physicochemical principles governing surfaces, interfaces, colloidal stability, aggregation, adsorption, and emulsification.
- To develop competency in modeling and analyzing interfacial phenomena, surface thermodynamics, and colloidal interactions.
- To familiarize students with characterization techniques for surface and colloidal systems, including spectroscopic, microscopic, rheological, and scattering methods.
- To enable students to apply colloid and interface science principles to industrial processes such as detergency, paints, catalysis, drug delivery, wastewater treatment, and nanotechnology.

**Course Content:**

| Module | Content | Hour | Weightage In % |
|---|---|---|---|
| 1 | **Introduction to Colloids and Interfaces** Colloids, dispersed phase, continuous phase, surface energy, interfacial tension, Gibbs adsorption, Brownian motion, colloidal size range, DLVO theory (intro), surfactant basics, micelles, emulsions, aerosols, suspensions, foams, lyophobic colloids, lyophilic colloids, electric double layer. | 5 | 10 |
| 2 | **Surface Thermodynamics and Interfacial Phenomena** Surface tension, work of adhesion, work of cohesion, Young–Laplace equation, capillarity, wetting, contact angle, spreading coefficient, surface excess, Gibbs adsorption isotherm, Marangoni effect, interfacial stability, Laplace pressure, detergency, foaming, anti-foaming agents. | 7 | 20 |
| 3 | **Surfactants, Micelles, and Self-Assembly** Surfactants, CMC (critical micelle concentration), HLB value, self-assembly, micelles, reverse micelles, bilayers, vesicles, block copolymers, amphiphiles, ionic surfactants, nonionic | 5 | 10 |

| | | | |
|---|---|---|---|
| | surfactants, Krafft temperature, cloud point, phase behavior, microemulsions. | | |
| 4 | **Colloidal Interactions and Stability (DLVO Theory)**<br>DLVO theory, van der Waals forces, electrostatic interactions, zeta potential, electric double layer, Debye length, agglomeration, coagulation, flocculation, steric stabilization, depletion stabilization, osmotic pressure, repulsive barrier, attractive potential, colloidal stability. | 5 | 10 |
| 5 | **Micellization thermodynamics and self-assembly calculations**<br>Rheology, viscosity, viscoelasticity, shear thinning, shear thickening, thixotropy, yield stress, particle diffusion, sedimentation, Stokes law, Einstein viscosity, Brownian motion, Fokker–Planck equation (intro), colloidal gels, concentrated suspensions, Bingham fluids. | 5 | 10 |
| 6 | **Adsorption and Interfacial Engineering**<br>Adsorption, Langmuir isotherm, BET isotherm, Freundlich isotherm, adsorption kinetics, surface area, porosity, activated carbon, catalysts, functionalized surfaces, interface engineering, wettability modification, flotation, detergency, adhesion, surface coatings. | 8 | 20 |
| 7 | **Characterization Techniques for Colloids and Interfaces**<br>SEM, TEM, AFM, DLS (dynamic light scattering), zeta potential measurement, UV–Vis spectroscopy, FTIR, XRD, rheometry, particle size distribution, surface area (BET), contact angle goniometry, scattering techniques (SAXS, SANS), electrophoresis, TGA/DSC. | 5 | 10 |
| 8 | **Industrial Applications of Colloid and Interface Science**<br>Drug delivery, emulsions, food technology, detergents, enhanced oil recovery, wastewater treatment, nanotechnology, paints and coatings, cosmetics, inks, catalysis, flotation, polymer latex, agrochemicals, pharmaceuticals, personal care products. | 5 | 10 |
| | **Total** | **45** | **100** |

**Tutorials**

| Tutorial | Content | Duration (Hours) |
|---|---|---|
| 1 | Introduction to colloids; classification; particle size; dispersed systems | 1 |
| 2 | Surface energy, interfacial tension, Laplace equation | 1 |
| 3 | Wetting, contact angle measurement, spreading coefficient | 2 |
| 4 | Surfactants and CMC determination problems | 2 |
| 5 | Micellization thermodynamics and self-assembly calculations | 2 |
| 6 | Electric double layer, zeta potential, Debye length | 2 |
| 7 | DLVO theory derivation and applications | 2 |
| 8 | Colloidal stability, coagulation, flocculation analysis | 2 |
| 9 | Rheology calculations: viscosity, shear stress, flow curves | 2 |
| 10 | Sedimentation, diffusion, Stokes law numerical problems | 2 |
| 11 | Adsorption isotherm calculations (Langmuir, BET) | 2 |
| 12 | Surface area and porosity evaluation exercises | 2 |

| | | |
|---|---|---|
| 13 | Characterization techniques: DLS, SEM/TEM, AFM | 2 |
| 14 | Industrial case study: wastewater treatment, paints, emulsions | 2 |
| 15 | Nanomaterial and interfacial engineering design problems | 2 |

**Text Book:**

| Title | Author(s) | Publication |
|---|---|---|
| Colloid and Interface Science | P. C. Hiemenz, Raj Rajagopalan | CRC Press |

**Reference Books:**

| Title | Author(s) | Publication |
|---|---|---|
| Intermolecular and Surface Forces | Jacob N. Israelachvili | Academic Press |
| Colloidal Dispersions | W. B. Russel, D. A. Saville, W. R. Schowalter | Cambridge University Press |
| Introduction to Surface Chemistry and Catalysis | Gabor A. Somorjai, Y. Li | Wiley |

**Course Evaluation:**

**Theory:**

- Continuous Evaluation consists of two tests, each of 30 marks with a duration of 1 hour.
- Faculty Evaluation consists of 10 marks, as per the guidelines provided by the Course Coordinator.
- End Semester Examination will consist of a comprehensive 60 marks theory exam.

**Tutorials:**

- Continuous Evaluation consists of the performance in tutorials, which should be evaluated out of 10 marks for each tutorial in the next session. The average of these will be converted to 10 marks.
- Internal Viva component of 10 marks based on tutorial understanding and application.
- Tutorial-based assignment/quiz/problem-solving test of 20 marks during the End Semester Evaluation.
- Viva/Oral performance during the End Semester Evaluation carrying 10 marks.

**Course Outcome(s):**

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

| SECH8530 | Introduction To Colloid And Interface Science And Engineering |
|---|---|
| CO 1 | Understand and explain fundamental principles of colloid and interface science, including surface thermodynamics and colloidal classifications. |
| CO 2 | Analyze colloidal stability using DLVO theory and evaluate effects of intermolecular forces, electrolytes, and surfactants. |

| | |
|---|---|
| CO 3 | Apply rheological and dynamic principles to characterize flow behavior, diffusion, and sedimentation in colloidal systems. |
| CO 4 | Use characterization tools (DLS, SEM, AFM, zeta potential, rheometry) to analyze colloids and interfaces. |
| CO 5 | Apply principles of interfacial engineering in real industrial applications such as detergency, catalysis, nanotechnology, pharmaceuticals, and wastewater treatment. |

**Mapping of CO with PO**

| SECH8530 | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CO 1 | 3 | 2 | | 2 | | | | | | | |
| CO 2 | 2 | 3 | | 3 | 2 | | | | | | |
| CO 3 | 2 | 3 | 3 | 3 | 3 | | | | | | |
| CO 4 | 1 | 2 | 3 | 2 | 2 | | | | | 2 | |
| CO 5 | | | | | | | | 3 | 3 | 3 | 2 |

**Mapping of CO with PSO**

| SECH8530 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|
| CO 1 | 2 | 2 | 1 |
| CO 2 | 3 | 2 | 2 |
| CO 3 | 3 | 3 | 2 |
| CO 4 | 2 | 3 | 2 |
| CO 5 | 1 | 2 | 3 |

Level of Bloom's Revised Bloom's Taxonomy in Assessment

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

| Module No | Content | RBT Level |
|---|---|---|
| 01 | Introduction to Colloids and Interfaces | 3,5 |
| 02 | Surface Thermodynamics and Interfacial Phenomena | 1,4 |
| 03 | Surfactants, Micelles, and Self-Assembly | 1,3 |
| 04 | Colloidal Interactions and Stability (DLVO Theory) | 2,6 |
| 05 | Rheology and Dynamics of Colloidal Systems | 1,5 |
| 06 | Adsorption and Interfacial Engineering | 3,4 |
| 07 | Characterization Techniques for Colloids and Interfaces | 2,4 |
| 08 | Industrial Applications of Colloid and Interface Science | 3,4 |

**P P Savani University**
**School of Engineering**

**Department of Chemical Engineering**

Course Code: SECH8540
Course Name: Mathematical Modelling And Simulation Of Chemical Engineering Process
Prerequisite Course(s): -

**Teaching & Examination Scheme**

| Teaching Scheme (Hours/Week) | | | | Examination Scheme (Marks) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Theory | Practical | Tutorial | Credit | Theory | | Practical | | Tutorial | | Total |
| | | | | CE | ESE | CE | ESE | CE | ESE | |
| 3 | - | 2 | 5 | 40 | 60 | 0 | 0 | 40 | 60 | 200 |

CE: Continuous Evaluation, ESE: End Semester Exam

**Objective(s) of the course:**

- To introduce mathematical formulation of chemical engineering systems using fundamental conservation principles and engineering assumptions.
- To develop the ability to solve linear/nonlinear algebraic, ODE, and PDE models relevant to chemical processes using analytical and numerical methods.
- To enable students to perform steady-state and dynamic simulations of reactors, separation units, heat-transfer systems, and integrated processes.
- To familiarize students with computational tools such as MATLAB, Python, Aspen Plus, and Scilab for solving, analyzing, and visualizing process models.
- To strengthen skills in model verification, validation, parameter estimation, sensitivity analysis, and optimization for real-world applications.

**Course Content:**

| Module | Content | Hour | Weightage In % |
|---|---|---|---|
| 1 | **Introduction to Mathematical Modelling in Chemical Engineering** mathematical modelling, abstraction, assumptions, process variables, parameters, degrees of freedom, steady-state models, dynamic models, lumped systems, distributed systems, black-box model, mechanistic model, empirical model, conservation equations, model classification, scaling & dimensional analysis. | 5 | 10 |
| 2 | **Formulation of Process Models Using Conservation Laws** mass balance, energy balance, component balance, momentum balance, generation term, accumulation term, transport phenomena, boundary conditions, constitutive equations, reaction kinetics, thermodynamic relations, process flow structures, recycle systems, bypass systems, purge systems. | 7 | 20 |
| 3 | **Mathematical Models of Chemical Reactors** | 5 | 10 |

| | | | |
|---|---|---|---|
| | CSTR modelling, PFR modelling, batch reactor, reaction kinetics, non-isothermal reactor, adiabatic reactor, catalytic reactor, residence time distribution (RTD), dynamic behaviour, stability, multiple steady states, reactor design equations, coupled differential equations, reaction networks, reactor scale-up, energy–mass coupling. | | |
| 4 | **Models of Heat Transfer and Separation Processes** conduction model, convection model, heat exchanger modelling, LMTD, NTU, distillation column modelling, equilibrium stages, mass transfer coefficients, absorption model, stripping model, membrane separation, drying models, diffusivity, heat–mass coupling, unsteady-state heat transfer, transport-limited models. | 5 | 10 |
| 5 | **Numerical Methods for Model Solution** algebraic equations, ODE solvers, PDE discretization, finite difference method, finite volume method, explicit schemes, implicit schemes, Newton–Raphson, convergence criteria, error analysis, stiffness, stability analysis, interpolation, numerical integration, iterative methods, matrix operations. | 5 | 10 |
| 6 | **Dynamic Simulation and Process Control Models** dynamic simulation, transient behaviour, FOPTD model, SOPTD model, Laplace transform, transfer function, state-space modelling, system identification, feedback control, feedforward control, linearization, stability analysis, dynamic response, perturbations, control loops. | 8 | 20 |
| 7 | **Simulation Tools and Software for Chemical Engineering** MATLAB scripting, Python modelling, SciPy libraries, NumPy arrays, ODE solvers, simulation workflow, Aspen Plus flowsheeting, thermodynamic packages, property estimation, sensitivity analysis, parametric simulation, computational graphs, numerical visualization, plotting tools, simulation validation. | 5 | 10 |
| 8 | **Model Verification, Validation, Optimization and Case Studies** model validation, verification, calibration, parameter estimation, optimization techniques, objective function, constraints, gradient methods, heuristic algorithms, error minimization, sensitivity analysis, uncertainty quantification, process optimization, real-time modelling, case-study analysis. | 5 | 10 |
| | **Total** | **45** | **100** |

**Tutorials**

| Tutorial | Content | Duration (Hours) |
|---|---|---|
| 1 | Introduction to modelling, assumptions, degrees of freedom | 1 |
| 2 | Mass balance model formulation problems | 1 |
| 3 | Energy balance models for non-isothermal systems | 2 |
| 4 | Reactor modelling – batch, CSTR, PFR | 2 |
| 5 | Multiple steady states and stability in reactors | 2 |
| 6 | Modelling of mixing tanks, recycle/bypass systems | 2 |

| | | |
|---|---|---|
| 7 | Modelling of heat exchangers and dryers | 2 |
| 8 | Distillation and absorption column modelling | 2 |
| 9 | PDE formulation for transport processes | 2 |
| 10 | Numerical ODE solution using MATLAB/Python | 2 |
| 11 | Finite difference method for PDE | 2 |
| 12 | Dynamic simulation and linearization | 2 |
| 13 | Transfer function models and response analysis | 2 |
| 14 | Aspen Plus flowsheet modelling & sensitivity analysis | 2 |
| 15 | Model validation, parameter estimation & optimization case study | 2 |

**Text Book:**

| Title | Author(s) | Publication |
|---|---|---|
| Mathematical Modeling in Chemical Engineering | A. W. Westerberg & W. L. Luyben | Prentice Hall |

**Reference Books:**

| Title | Author(s) | Publication |
|---|---|---|
| Process Modelling, Simulation and Control for Chemical Engineers | William L. Luyben | McGraw-Hill |
| Modeling and Simulation in Chemical Engineering | R. L. Motard & M. F. Malone | CRC Press |

**Course Evaluation:**

**Theory:**

- Continuous Evaluation consists of two tests, each of 30 marks with a duration of 1 hour.
- Faculty Evaluation consists of 10 marks, as per the guidelines provided by the Course Coordinator.
- End Semester Examination will consist of a comprehensive 60 marks theory exam.

**Tutorials:**

- Continuous Evaluation consists of the performance in tutorials, which should be evaluated out of 10 marks for each tutorial in the next session. The average of these will be converted to 10 marks.
- Internal Viva component of 10 marks based on tutorial understanding and application.
- Tutorial-based assignment/quiz/problem-solving test of 20 marks during the End Semester Evaluation.
- Viva/Oral performance during the End Semester Evaluation carrying 10 marks.

**Course Outcome(s):**

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

| SECH8540 | Mathematical Modelling And Simulation Of Chemical Engineering Process |
|---|---|
| CO 1 | Formulate mathematical models of reactors, heat-transfer units, separation processes, and integrated systems using conservation principles. |

| | |
|---|---|
| CO 2 | Apply numerical methods to solve algebraic, ODE, and PDE models relevant to chemical engineering systems. |
| CO 3 | Perform steady-state and dynamic simulations using MATLAB, Python, and Aspen Plus. |
| CO 4 | Analyze process behaviour through sensitivity analysis, parameter estimation, and model optimization. |
| CO 5 | Validate engineering models and interpret simulation results for industrial decision-making and design improvements. |

**Mapping of CO with PO**

| SECH8540 | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CO 1 | 3 | 2 | | 2 | | | | | | | |
| CO 2 | 2 | 3 | | 3 | 2 | | | | | | |
| CO 3 | 2 | 3 | 3 | 3 | 3 | | | | | | |
| CO 4 | 1 | 2 | 3 | 2 | 2 | | | | | 2 | |
| CO 5 | | | | | | | | 3 | 3 | 3 | 2 |

**Mapping of CO with PSO**

| SECH8540 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|
| CO 1 | 2 | 2 | 1 |
| CO 2 | 3 | 2 | 2 |
| CO 3 | 3 | 3 | 2 |
| CO 4 | 2 | 3 | 2 |
| CO 5 | 1 | 2 | 3 |

Level of Bloom's Revised Bloom's Taxonomy in Assessment

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

| Module No | Content | RBT Level |
|---|---|---|
| 01 | Introduction to Mathematical Modelling in Chemical Engineering | 3,5 |
| 02 | Formulation of Process Models Using Conservation Laws | 1,4 |
| 03 | Mathematical Models of Chemical Reactors | 1,3 |
| 04 | Models of Heat Transfer and Separation Processes | 2,6 |
| 05 | Numerical Methods for Model Solution | 1,5 |
| 06 | Dynamic Simulation and Process Control Models | 3,4 |
| 07 | Simulation Tools and Software for Chemical Engineering | 2,4 |
| 08 | Model Verification, Validation, Optimization and Case Studies | 3,4 |

**P P Savani University**
**School of Engineering**
**Department of Chemical Engineering**

Course Code: SECH8550
Course Name: Chemical Process Safety
Prerequisite Course(s): -

**Teaching & Examination Scheme**

| Teaching Scheme (Hours/Week) | | | | Examination Scheme (Marks) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Theory | Practical | Tutorial | Credit | Theory | | Practical | | Tutorial | | Total |
| | | | | CE | ESE | CE | ESE | CE | ESE | |
| 3 | - | 2 | 5 | 40 | 60 | 0 | 0 | 40 | 60 | 200 |

CE: Continuous Evaluation, ESE: End Semester Exam

**Objective(s) of the course:**

- To provide fundamental knowledge of process safety principles, hazard identification techniques, and accident prevention strategies used in chemical industries.
- To introduce students to risk assessment, fire and explosion mechanisms, toxic release modeling, and quantitative safety evaluation.
- To familiarize learners with industrial safety regulations, safety instrumentation, and inherently safer process design approaches.
- To train students in applying hazard analysis tools such as HAZOP, FTA, ETA, LOPA, and safety audits for real industrial problems.
- To build competence in emergency response planning, safety management systems, and analysis of case studies of major industrial accidents.

**Course Content:**

| Module | Content | Hour | Weightage In % |
|---|---|---|---|
| 1 | **Introduction to Chemical Process Safety** process safety, loss prevention, industrial hazards, accident causation, hazard triangle, risk, risk matrix, safety culture, inherently safer design, process lifecycle, safety audit, accident statistics, human factors, regulatory agencies, safety standards. | 5 | 10 |
| 2 | **Toxicology and Industrial Hygiene** toxicity, dose–response curve, threshold limit value (TLV), IDLH, $LD_{50}$, $LC_{50}$, exposure pathways, occupational hygiene, ventilation, air monitoring, toxic release, safety data sheets (SDS), biological hazards, chronic exposure, acute exposure. | 7 | 20 |
| 3 | **Fire, Explosion & Hazardous Reactions** flammability limits, flash point, auto-ignition temperature, detonation, deflagration, BLEVE, vapor cloud explosion, dust explosion, runaway reaction, thermal stability, relief systems, fire triangle, combustion mechanism, ignition sources, explosion indices. | 5 | 10 |

| | | | |
|---|---|---|---|
| 4 | **Hazard Identification Techniques (HAZID & HAZOP)** hazard identification, HAZOP, guide words, deviation analysis, P&ID interpretation, preliminary hazard analysis (PHA), checklist method, what-if analysis, safety review, operability issues, hazard scenarios, consequence identification, team-based analysis, process deviations, risk ranking. | 5 | 10 |
| 5 | **Risk Assessment & Quantitative Techniques** risk assessment, QRA, fault tree analysis (FTA), event tree analysis (ETA), LOPA, risk matrix, individual risk, societal risk, frequency analysis, consequence modeling, probability estimation, SIL rating, scenario development, severity assessment, outcome modeling. | 5 | 10 |
| 6 | **Safety Instrumentation & Inherently Safer Design** safety instrumented system (SIS), safety integrity level (SIL), alarms, interlocks, control loops, redundancy, fail-safe design, relief valve, rupture disks, passive safety, substitution, minimization, moderation, simplification, process containment. | 8 | 20 |
| 7 | **Relief Systems, Ventilation & Emergency Planning** relief valve sizing, vent design, emergency venting, flare systems, dispersion modeling, evacuation planning, shelter-in-place, emergency response, ventilation design, containment, spill control, fire protection systems, foam systems, sprinkler systems, emergency preparedness. | 5 | 10 |
| 8 | **Industrial Case Studies & Accident Investigation** root cause analysis, Bow-tie analysis, accident reconstruction, human error, equipment failure, process deviation, lessons learned, refinery accidents, chemical plant disasters, Bhopal tragedy, Flixborough, Piper Alpha, hierarchy of controls, incident reporting, safety improvement. | 5 | 10 |
| | **Total** | **45** | **100** |

**Tutorials**

| Tutorial | Content | Duration (Hours) |
|---|---|---|
| 1 | Meaning & scope of chemical process safety, loss prevention, safety triangle | 1 |
| 2 | Industrial hazards, risk matrix, safety culture concepts | 1 |
| 3 | Toxicology basics, dose–response curves, TLV, IDLH | 2 |
| 4 | Industrial hygiene: ventilation, sampling, SDS interpretation | 2 |
| 5 | Fire & explosion fundamentals, flammability diagrams | 2 |
| 6 | Vapor cloud explosion, BLEVE, dust explosion case studies | 2 |
| 7 | Runaway reaction analysis using data & examples | 2 |
| 8 | Hazard identification tools (checklists, what-if, PHA) | 2 |
| 9 | HAZOP guide words, deviation table preparation | 2 |
| 10 | FTA preparation, Boolean logic simplification | 2 |
| 11 | ETA development for release scenarios | 2 |
| 12 | LOPA basics, risk reduction factor calculations | 2 |
| 13 | SIS & SIL concepts with examples | 2 |
| 14 | Relief valve sizing problems, emergency planning | 2 |
| 15 | Case studies: Bhopal, Texas City, Flixborough, lessons learned | 2 |

**Text Book:**

| Title | Author(s) | Publication |
|---|---|---|
| Chemical Process Safety: Fundamentals with Applications | Daniel A. Crowl & Joseph F. Louvar | Prentice Hall |

**Reference Books:**

| Title | Author(s) | Publication |
|---|---|---|
| Loss Prevention in the Process Industries | Frank P. Lees | Elsevier |
| Industrial Safety and Hazard Control | A.K. Gupta | Laxmi Publications |

**Course Evaluation:**

**Theory:**

- Continuous Evaluation consists of two tests, each of 30 marks with a duration of 1 hour.
- Faculty Evaluation consists of 10 marks, as per the guidelines provided by the Course Coordinator.
- End Semester Examination will consist of a comprehensive 60 marks theory exam.

**Tutorials:**

- Continuous Evaluation consists of the performance in tutorials, which should be evaluated out of 10 marks for each tutorial in the next session. The average of these will be converted to 10 marks.
- Internal Viva component of 10 marks based on tutorial understanding and application.
- Tutorial-based assignment/quiz/problem-solving test of 20 marks during the End Semester Evaluation.
- Viva/Oral performance during the End Semester Evaluation carrying 10 marks.

**Course Outcome(s):**

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

| SECH8550 | Chemical Process Safety |
|---|---|
| CO 1 | Identify various chemical process hazards and evaluate their potential impact on industrial operations. |
| CO 2 | Apply toxicology, fire & explosion fundamentals, and hazardous reaction principles to real industrial scenarios. |
| CO 3 | Perform hazard identification studies using HAZOP, PHA, checklists, and qualitative risk tools. |
| CO 4 | Conduct quantitative risk assessments using FTA, ETA, LOPA, and consequence modeling. |
| CO 5 | Recommend appropriate safety systems, relief devices, and emergency response strategies for chemical plants. |

**Mapping of CO with PO**

| SECH8550 | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CO 1 | 3 | 2 | | 2 | | | | | | | |
| CO 2 | 2 | 3 | | 3 | 2 | | | | | | |
| CO 3 | 2 | 3 | 3 | 3 | 3 | | | | | | |
| CO 4 | 1 | 2 | 3 | 2 | 2 | | | | | 2 | |
| CO 5 | | | | | | | | 3 | 3 | 3 | 2 |

**Mapping of CO with PSO**

| SECH8550 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|
| CO 1 | 2 | 2 | 1 |
| CO 2 | 3 | 2 | 2 |
| CO 3 | 3 | 3 | 2 |
| CO 4 | 2 | 3 | 2 |
| CO 5 | 1 | 2 | 3 |

Level of Bloom's Revised Bloom's Taxonomy in Assessment

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

| Module No | Content | RBT Level |
|---|---|---|
| 01 | **Introduction to Chemical Process Safety** | 3,5 |
| 02 | **Toxicology and Industrial Hygiene** | 1,4 |
| 03 | Fire, Explosion & Hazardous Reactions | 1,3 |
| 04 | Hazard Identification Techniques (HAZID & HAZOP) | 2,6 |
| 05 | Risk Assessment & Quantitative Techniques | 1,5 |
| 06 | Safety Instrumentation & Inherently Safer Design | 3,4 |
| 07 | Relief Systems, Ventilation & Emergency Planning | 2,4 |
| 08 | Industrial Case Studies & Accident Investigation | 3,4 |

## P P Savani University
## School of Engineering
## Department of Chemical Engineering

Course Code: SECH8560
Course Name: Corrosion/Environmental Degradation/Surface Engineering
Prerequisite Course(s): -

**Teaching & Examination Scheme**

| Teaching Scheme (Hours/Week) | | | | Examination Scheme (Marks) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Theory | Practical | Tutorial | Credit | Theory | | Practical | | Tutorial | | Total |
| | | | | CE | ESE | CE | ESE | CE | ESE | |
| 3 | - | 2 | 5 | 40 | 60 | 0 | 0 | 40 | 60 | 200 |

CE: Continuous Evaluation, ESE: End Semester Exam

**Objective(s) of the course:**

- To develop an understanding of corrosion fundamentals, environmental degradation mechanisms, and their relevance to industrial applications.
- To explain electrochemical principles, corrosion thermodynamics, kinetics, and predictive models.
- To analyze material degradation in aggressive environments such as marine, soil, atmospheric, chemical, and high-temperature conditions.
- To familiarize students with surface engineering technologies including coatings, diffusion treatments, and advanced protective systems.
- To enhance competency in corrosion testing, monitoring, failure analysis, and preventive strategies based on industrial standards.

**Course Content:**

| Module | Content | Hour | Weightage In % |
|---|---|---|---|
| 1 | **Introduction to Corrosion and Environmental Degradation** corrosion, material degradation, electrochemical processes, metallic corrosion, aqueous corrosion, oxidation, corrosion cells, corrosion products, galvanic action, corrosion rate, localised attack, corrosion monitoring, metallic failure, industrial corrosion, environmental factors. | 5 | 10 |
| 2 | **Electrochemical Principles of Corrosion** electrode potential, Nernst equation, galvanic series, anodic reaction, cathodic reaction, passivation, Pourbaix diagrams, Evans diagram, corrosion thermodynamics, polarization, activation control, concentration polarization, mixed potential theory, electrochemical kinetics, pitting potential. | 7 | 20 |
| 3 | **Forms of Corrosion and Environmental Effects** uniform corrosion, galvanic corrosion, pitting corrosion, crevice corrosion, intergranular corrosion, stress corrosion cracking (SCC), hydrogen embrittlement, erosion–corrosion, MIC (microbial induced corrosion), atmospheric corrosion, | 5 | 10 |

| | | | |
|---|---|---|---|
| | marine environment, soil corrosion, differential aeration, chloride attack, corrosion morphology. | | |
| 4 | **High-Temperature Corrosion and Oxidation** oxidation kinetics, parabolic rate law, linear oxidation, oxide scale formation, spalling, carburization, sulfidation, nitridation, molten salt corrosion, hot corrosion, diffusion processes, high-temperature alloys, scale adherence, oxide microstructure, thermochemical degradation. | 5 | 10 |
| 5 | **Corrosion Prevention and Control Methods** cathodic protection, sacrificial anodes, impressed current system, anodic protection, corrosion inhibitors, passivators, coatings, material selection, protective design, corrosion allowance, environmental control, oxygen scavengers, protective linings, corrosion-resistant alloys, mitigation strategies. | 5 | 10 |
| 6 | **Surface Engineering for Corrosion Resistance** thermal spraying, PVD coating, CVD coating, diffusion coatings, nitriding, carburizing, overlay coatings, electroplating, anodizing, conversion coatings, polymer coatings, ceramic coatings, surface modification, wear resistance, tribological protection. | 8 | 20 |
| 7 | **Corrosion Testing and Monitoring** afel polarization, electrochemical impedance spectroscopy (EIS), weight loss test, corrosion rate calculation, ASTM G standards, potentiodynamic scan, linear polarization resistance (LPR), open circuit potential (OCP), electrochemical noise, NDT methods, ultrasonic testing, XRD analysis, SEM morphology, corrosion sensors, monitoring techniques. | 5 | 10 |
| 8 | **Industrial Case Studies and Failure Analysis** failure analysis, fracture surface examination, SEM fractography, pit morphology, root cause analysis, refinery failures, marine corrosion failures, pipeline corrosion, chemical plant degradation, boiler tube failures, SCC failures, material selection errors, environmental contribution, failure prevention, industrial standards. | 5 | 10 |
| | **Total** | **45** | **100** |

**Tutorials**

| Tutorial | Content | Duration (Hours) |
|---|---|---|
| 1 | Basic corrosion terminology, cost of corrosion, classification | 1 |
| 2 | Electrochemical cell representation and electrode potentials | 1 |
| 3 | Pourbaix diagrams and passivation study | 2 |
| 4 | Uniform, galvanic, pitting corrosion examples | 2 |
| 5 | SCC, hydrogen embrittlement, MIC discussions | 2 |
| 6 | Atmospheric, marine and soil corrosion cases | 2 |
| 7 | Oxidation kinetics and scale adherence | 2 |
| 8 | Corrosion allowance and material selection charts | 2 |
| 9 | Cathodic protection design problems | 2 |
| 10 | Inhibitor efficiency calculations | 2 |

| | | |
|---|---|---|
| 11 | Surface coatings: metallic, polymeric, ceramic | 2 |
| 12 | Thermal spray and PVD/CVD case examples | 2 |
| 13 | Electrochemical testing (Tafel, EIS) | 2 |
| 14 | ASTM standards for corrosion testing | 2 |
| 15 | Failure analysis review (oil & gas, marine) | 2 |

**Text Book:**

| Title | Author(s) | Publication |
|---|---|---|
| Corrosion Engineering | Mars G. Fontana | McGraw-Hill Education |

**Reference Books:**

| Title | Author(s) | Publication |
|---|---|---|
| Principles and Prevention of Corrosion | Denny A. Jones | Pearson Education |
| Corrosion and Surface Engineering | K. G. Budinski | Prentice Hall |

**Course Evaluation:**

**Theory:**

- Continuous Evaluation consists of two tests, each of 30 marks with a duration of 1 hour.
- Faculty Evaluation consists of 10 marks, as per the guidelines provided by the Course Coordinator.
- End Semester Examination will consist of a comprehensive 60 marks theory exam.

**Tutorials:**

- Continuous Evaluation consists of the performance in tutorials, which should be evaluated out of 10 marks for each tutorial in the next session. The average of these will be converted to 10 marks.
- Internal Viva component of 10 marks based on tutorial understanding and application.
- Tutorial-based assignment/quiz/problem-solving test of 20 marks during the End Semester Evaluation.
- Viva/Oral performance during the End Semester Evaluation carrying 10 marks.

**Course Outcome(s):**

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

| SECH8560 | Corrosion/Environmental Degradation/Surface Engineering |
|---|---|
| CO 1 | Explain corrosion fundamentals, mechanisms, and environmental effects. |
| CO 2 | Apply electrochemical theory to predict and analyze corrosion behavior. |
| CO 3 | Identify forms of corrosion and evaluate material/environment interactions. |
| CO 4 | Conduct corrosion testing, interpret data, and follow ASTM standards. |
| CO 5 | Perform basic failure analysis and propose preventive strategies for industrial systems. |

**Mapping of CO with PO**

| SECH8560 | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CO 1 | 3 | 2 | | 2 | | | | | | | |
| CO 2 | 2 | 3 | | 3 | 2 | | | | | | |
| CO 3 | 2 | 3 | 3 | 3 | 3 | | | | | | |
| CO 4 | 1 | 2 | 3 | 2 | 2 | | | | | 2 | |
| CO 5 | | | | | | | | 3 | 3 | 3 | 2 |

**Mapping of CO with PSO**

| SECH8560 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|
| CO 1 | 2 | 2 | 1 |
| CO 2 | 3 | 2 | 2 |
| CO 3 | 3 | 3 | 2 |
| CO 4 | 2 | 3 | 2 |
| CO 5 | 1 | 2 | 3 |

Level of Bloom's Revised Bloom's Taxonomy in Assessment

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

| Module No | Content | RBT Level |
|---|---|---|
| 01 | Introduction to Corrosion and Environmental Degradation | 3,5 |
| 02 | Electrochemical Principles of Corrosion | 1,4 |
| 03 | Forms of Corrosion and Environmental Effects | 1,3 |
| 04 | High-Temperature Corrosion and Oxidation | 2,6 |
| 05 | Corrosion Prevention and Control Methods | 1,5 |
| 06 | Surface Engineering for Corrosion Resistance | 3,4 |
| 07 | Corrosion Testing and Monitoring | 2,4 |
| 08 | Industrial Case Studies and Failure Analysis | 3,4 |

## P P Savani University
## School of Engineering
## Department of Chemical Engineering

Course Code: SECH8920
Course Name: Research Project-IV
Prerequisite Course/s: -

**Teaching & Examination Scheme:**

| Teaching Scheme (Hours/Week) | | | | Examination Scheme (Marks) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Theory | Practical | Tutorial | Credit | Theory | | Practical | | Tutorial | | Total |
| | | | | CE | ESE | CE | ESE | CE | ESE | |
| - | 10 | - | 10 | - | - | 80 | 120 | - | - | 200 |

CE: Continuous Evaluation, ESE: End Semester Exam

**Objective(s) of the course:**

To help learners to

- To engage students in identifying, formulating, and solving real-world research problems.
- To encourage independent and original thinking in designing, implementing, and evaluating computational methods.
- To promote the use of research methodology, scientific writing, and effective communication of results.

**List of Practical's:**

| Sr. No. | Name of Practical | Hours |
|---|---|---|
| 1. | Orientation, topic finalization, and problem statement definition. | 10 |
| 2. | Literature review using IEEE/ACM/ScienceDirect databases. | 20 |
| 3 | Identification of research gap and formulation of research objectives. | 10 |
| 4 | Selection of methodology, tools, and technologies. | 10 |
| 5 | Initial prototype design or dataset collection/preprocessing. | 10 |
| 6 | Core development: algorithm/model/system design begins. | 10 |
| 7 | Implementation continues with performance testing. | 30 |
| 8 | Experimentation, result collection, tuning. | 20 |
| 9 | Result validation (graphs, statistical methods, comparisons). | 20 |
| 10 | Drafting research report/paper, presentation preparation | 10 |
| | **TOTAL** | **150** |

**Practical:**

- Each student should be assigned a faculty guide.
- Regular weekly review meetings are mandatory.
- Mid-term internal evaluation and final external viva should be scheduled.
- Research should ideally be aligned with current thrust areas: chemical engineering, material science etc.

**Course Outcome(s):**

After the completion of the course, the student will be able to

| SECH8920 | Research Project-IV |
|---|---|
| CO1 | Identify and define a research problem with reference to current trends in Chemical Engineering. |
| CO2 | Analyze relevant literature and select appropriate tools and techniques. |
| CO3 | Develop and implement innovative solutions or models for real-world problems. |
| CO4 | Evaluate research findings and present technical documentation and publications. |
| CO 5 | Exhibit professional ethics, teamwork, and project management skills in executing a research project. |

**Mapping of CO with PO**

| SECH8920 | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CO 1 | 3 | 2 | | 2 | | | | | | | |
| CO 2 | 2 | 3 | | 3 | 2 | | | | | | |
| CO 3 | 2 | 3 | 3 | 3 | 3 | | | | | | |
| CO 4 | 1 | 2 | 3 | 2 | 2 | | | | | 2 | |
| CO 5 | | | | | | | | 3 | 3 | 3 | 2 |

**Mapping of CO with PSO**

| SECH8920 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|
| CO 1 | 2 | 2 | 1 |
| CO 2 | 3 | 2 | 2 |
| CO 3 | 3 | 3 | 2 |
| CO 4 | 2 | 3 | 2 |
| CO 5 | 1 | 2 | 3 |