Shivaji University
Vidyanagar, Kolhapur - 416 004, Maharashtra.

Department of Technology

As per NEP2020 guidelines

Second Year B. Tech (Chemical Engineering), Detailed Curriculum w.e.f. 2024-25.

A. Engineering Graduate Attributes

1. Domain specific Engineering Knowledge
2. Problem Analysis Ability
3. Acquiring Skills that enable them to Design & Develop Solutions to the Problems
4. Capacity to investigate Complex Problems
5. Familiarity of using Modern Tools
6. Understanding Engineer's role and connectivity towards Society
7. Awareness about Environment & Sustainability
8. Practicing ethics and values
9. Ability to work as an Individual & in a Team also
10. Acquiring Communication skills
11. Becoming well verse with task of Project management & Finance aspects
12. Developing Lifelong Learning attitude

B. B. Tech (Chemical Engineering) Program: Vision, Mission, PEOs and POs.

Vision

"To develop a community of skilled Chemical Engineering graduates with ethical values, problem-solving skills, and social responsibility, ready to address challenges in industry and academia at all levels."

Mission

- Cultivate an innovative learning environment that equips students to excel in chemical engineering through creativity, problem-solving, and teamwork.
- Promote excellence in chemical engineering education, research, and outreach to advance the field and benefit society.
- Develop graduates with robust skills in communication, teamwork, and leadership to thrive in diverse professional settings.
- Foster entrepreneurial and ethical mind-sets, preparing students for significant impacts in their chemical engineering careers.
- Strengthen industry and academic partnerships to enrich students' practical experiences and foster professional and field advancement.

Program Educational Objectives (PEOs)

The Program Educational Objectives (PEOs) provides a clear vision for the long-term achievements of your program's graduates, guiding curriculum design and teaching practices to align with industry and societal needs. PEOs also serve as benchmarks for assessing program success and ensuring that graduates are prepared for their careers and lifelong learning.

1. **Career Excellence:** Prepare graduates with a strong foundation in chemical engineering principles and practices, enabling them to excel in industrial roles and pursue advanced studies.
2. **Professional Mastery:** Equip graduates with high-level skills in process design, plant operation, and project management for successful careers in chemical engineering.
3. **Continuous Learning and Leadership:** Nurture graduates who engage in lifelong learning and demonstrate innovation, creativity, and leadership in their professional lives.
4. **Social Impact:** Educate graduates to devise solutions for challenges at local, state, national, and global levels, promoting the well-being of society.
5. **Ethics and Sustainability:** Prepare graduates to be ethical and environmentally conscious professionals who prioritize sustainable development in their engineering practices.

Program Outcomes (POs)

Program Outcomes provide a clear roadmap for the education and development of chemical engineering students, ensuring that your program is effective, relevant, and aligned with industry standards and expectations.

1. **Domain Specific Engineering Knowledge:** Apply principles from mathematics, physics, chemistry, and engineering to solve complex chemical engineering problems.
2. **Problem Analysis Ability:** Develop skills to analyse and solve problems encountered in chemical and allied industries and consultancy services.
3. **Acquiring Skills to Design/Develop Solutions to Problems:** Design and manage chemical processes and systems while considering current and emerging industrial practices.
4. **Capacity to Investigate Complex Problems:** Identify new research areas and utilize advanced research methods to analyse data and draw conclusions, aiming for innovative solutions in chemical engineering.
5. **Modern Tool Usage:** Select and apply modern engineering and IT tools, including modeling and prediction techniques, to complex engineering tasks.
6. **The Engineer's Connectivity with Society:** Assess and address societal, health, safety, legal, and cultural issues with informed engineering judgement.
7. **Environment and Sustainability Awareness:** Understand and integrate environmental impacts and sustainability into engineering solutions.
8. **Practicing Ethics and Values:** Uphold professional ethics and responsibilities in engineering practice.
9. **Ability to Work as an Individual and in Team:** Work effectively both individually and as a part of diverse and multidisciplinary teams.
10. **Acquiring Communication Skills:** Communicate complex engineering information effectively through written reports, presentations, and interpersonal communication.
11. **Well Versed with Task of Project Management and Finance Aspects:** Apply engineering and management principles to lead and manage projects in

multidisciplinary environments.

12. **Life-Long Learning Attitude:** Recognize and engage in lifelong learning to stay abreast of technological advancements in engineering.

C. Component wise distribution of credits

(Expected range of credits as per AICTE & NEP2020 guidelines is 160-176)

Sr. No.	Category Suggested	Course Code	No. of Credits	Components %
1.	Humanities and Social Sciences including Management & Environment Courses	HSMEC	04	2.27
2.	Indian Knowledge System	IKS	05	2.84
3.	Ability Enhancement Course	AEC	03	1.70
4.	Value Education Courses	VEC	02	1.14
5.	Basic Science courses	BSC	27	15.34
6.	Engineering Science Courses including workshop, drawing, basics of civil/electrical/mechanical/computer etc.	ESC	34	19.32
7.	Professional Core Courses	PCC	56	31.82
8.	Professional Elective Courses relevant to chosen specialization/branch	PEC	12	6.82
9.	Open subjects – Electives from other technical and /or emerging subjects	OEC	06	3.41
10.	Project , Seminar and Internship	PSI	13	7.39
11.	Multidisciplinary Minor	MDM	14	7.95
12.	Vocational and Skill Enhancement Courses	VSEC	Audit Courses	-
13.	Project Based Learning	PBL		
14.	Mandatory Audit Courses [Some other courses Decided at the Institute level but that do not get fit in the credits]	MAC (HSMEC)*		
	Total		**176**	**100**

* Please note that most of the courses under HSMEC have been covered under audit courses.

Shivaji University, Kolhapur
Department of Technology

Second Year B. Tech (Chemical Engineering), Semester- III

Teaching and Evaluation Scheme

Sr. No.	Category	Course Code	Course Title	Hours per week			Contact Hours	Credits	Evaluation Scheme	
									Theory	Practical
				L	T	P			ISE:ESE	IE:EE
1.	Basic Science Course	BSC211	Applied Chemistry-I (Physical, Inorganic& Analytical)	03	-	02	05	04	30:70	50:50
2.	Basic Science course	BSC212	Engineering Mathematics – III	03	-	-	03	03	30:70	50:00
3.	Professional Core Courses	PCC 211	Fluid Flow Operations	03	01	02	06	05	30:70	50:50
4.	Professional Core Courses	PCC 212	Chemical Engineering Thermodynamics	03	01	-	04	04	30:70	00:00
5.	Engineering Science Courses	ESC211	Material Science & Engineering	03	-	-	03	03	30:70	00:00
6.	Ability Enhancement Courses	AEC211	Soft Skills Development	01	-	-	01	01	-	50:00
				-	-	-	-	**20**	**500**	**300**
7.	Project Based Learning	PBL211	Mini Project I & Industrial Visit	-	01	-	01	IE at Course in charge end		
8.	Humanities, Social Sciences, Management, Environment	HSMEC 211	Environmental Studies	02	-	-	02	University Exam at Semester End		
			Total Hours	18	03	04	**25**	-	-	-

Shivaji University, Kolhapur
Department of Technology

Second Year B. Tech (Chemical Engineering), Semester- IV

Teaching and Evaluation Scheme

Sr. No.	Category	Code	Course Title	Hours per week			Contact Hours	Credits	Evaluation Scheme	
									Theory	Practical
				L	T	P			ISE:ESE	IE:EE
1.	Basic Science Course	BSC 221	Applied Chemistry –II (Organic)	03	-	02	05	04	30:70	50:00
2.	Professional Core Course	PCC 221	Heat Transfer Operations	03	-	02	05	04	30:70	50:50
3.	Professional Core Course	PCC 222	Mechanical Operations	03	-	02	05	04	30:70	50:50
4.	Professional Core Course	PCC 223	Inorganic Chemical Technologies	03	-	-	03	03	30:70	00:00
5.	Professional Core Course	PCC 224	Chemical Process Calculations	03	01	-	04	04	30:70	00:00
6.	MDM Course	MDM 221	Multidisciplinary Minor Course I*	03	-	-	03	03	30:70	00:00
7.	Indian Knowledge Systems	IKS 221	Introduction to Performing Arts	01	-	-	01	01	-	50:00
				-	-	-	-	23	600	300
8.	Mandatory Audit Course	MAC 221	Aptitude Enhancement Course I	-	01	-	01	IE at Course in charge end		
9.	Project Based Learning	PBL221	Mini Project II & Industrial Visit	-	01	-	01	IE at Course in charge end		
10.	Humanities, Social Sciences, Management Environment	HSMEC 221	Environmental Studies	02	-	-	02	University Exam at year end		
			Total Hours	**21**	**03**	**06**	**30**	-	-	-

*Note: The MDM course will be from the chosen Multidisciplinary Minor Titles.

<table>
<tr><td>Year, Program, Semester</td><td colspan="7">S. Y. B. Tech (Chemical Engineering) , Part II ,Semester III</td></tr>
<tr><td>Course Code</td><td colspan="7">BSC211</td></tr>
<tr><td>Course Category</td><td colspan="7">Basic Science Course</td></tr>
<tr><td>Course title</td><td colspan="7">Applied Chemistry-I (Physical, Inorganic & Analytical) (Theory)</td></tr>
<tr><td rowspan="2">Teaching Scheme and Credits</td><td>L</td><td>T</td><td>P</td><td colspan="2">Total Contact Hours</td><td colspan="2">Total Credits</td></tr>
<tr><td>03</td><td>-</td><td>-</td><td colspan="2">03</td><td colspan="2">03</td></tr>
<tr><td rowspan="2">Evaluation Scheme</td><td colspan="2">ISE</td><td>ESE</td><td>IOE</td><td>IPE</td><td>EOE</td><td>EPE</td><td>Total</td></tr>
<tr><td colspan="2">30</td><td>70</td><td>-</td><td>-</td><td>-</td><td>-</td><td>100</td></tr>
<tr><td>Pre-requisites(if any)</td><td colspan="7">BSC111, BSC121</td></tr>
<tr><td>Course Rationale</td><td colspan="7">The course aims to cover the fundamental principles, reactions, and applications of organic chemistry relevant to engineering disciplines. Each module is designed to provide a comprehensive understanding of organic chemistry concepts and their engineering implications, preparing students for practical applications in their future careers.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">The Course Teacher will ensure to
1. Elaborate the fundamental principles of physical, inorganic, and analytical chemistry.
2. Define and explain basic concepts of chemical equilibrium, distribution laws.
3. Describe the basics of adsorption phenomenon, adsorption types, catalysts, types of catalysis.
4. Discuss various factors affecting reaction rate, basics of Chemical Kinetics and Photochemistry.
5. Develop analytical and problem-solving skills applicable to engineering problems.
6. Explore the applications of chemistry in engineering fields.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">Upon completion of this course, student should be able to
1. Apply stoichiometric principles to balance chemical equations and solve quantitative problems.
2. Memorize and the basic concepts of chemical equilibrium, various relevant laws.
3. Differentiate between types of adsorptions, catalysts and identify the use of these concepts.
4. Calculate rates of chemical reactions and identify the importance of various concepts pertaining to Photochemistry.
5. Explain the principles and applications of various analytical techniques, including spectroscopy and chromatography.
6. Analyse environmental issues related to pollution control and propose engineering solutions</td></tr>
</table>

Course Outcome and Program Outcome Mapping

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO1	3	3	-	-	-	-	-	-	-	-	-	-
CO2	3	-	-	-	-	-	-	-	-	-	-	-
CO3	3	-	1	-	-	-	-	-	-	-	-	-
CO4	3	-	2	2	-	-	-	-	-	-	-	-
CO5	3	-	-	-	1	-	-	-	-	-	-	-
CO6	3	-	-	-	-	-	3	3	2	2	-	2

Level of Mapping as: Low 1, Moderate 2, High 3

Unit No.	Course Content	Hours
I	**Introduction to Chemistry:** Basic concepts of chemistry, Atomic structure and periodic table, Chemical bonding and molecular structure, States of matter and properties, Chemical equations and stoichiometry.	05
II	**Chemical Equilibrium and Distribution Law:** Characteristics of chemical equilibrium, law of mass action, Equilibrium constants & their relationship, derivation of law of mass action from chemical potential, Van't Hoff reaction, absolute reaction rate of transition state theory, Introduction to theory of distribution, Nernst distribution law, conditions for the validity of the distribution law, explanation & limitations of distribution law, Henry's law, determination of equilibrium constant from distribution coefficient, applications of distribution law, numerical based on the above topics	08
III	**Adsorption and Catalysis:** Characteristics, types of adsorption-Types of isotherms–Freundlich adsorption isotherm, Langmuir adsorption isotherm, applications of adsorption. Characteristics of catalysts, types of catalysis: homogeneous-mechanism of acid-base catalysis, heterogeneous-intermediate compound formation, catalytic poisons, promoters, supported catalysis, solid catalysts like oxides, metal & zeolites, phase transfer catalysts, enzyme catalysts	08
IV	**Chemical Kinetics and Photochemistry:** The rate equation, factors affecting rate of reaction, order and molecularity of a reaction, half-life time of a reaction, methods of determining order of a reaction. reactions of fractional orders, theories of reaction rates, kinetics of fast reactions. Electromagnetic radiation, light adsorption, laws of photochemistry-Grotthuss-Draper law, Stark Einstein law and Lambert-Beer law, Chemiluminescence and photosensitization, quantum efficiency	07
V	**Introduction to analytical techniques:** Spectroscopy, chromatography, electrochemistry, Quantitative analysis: Gravimetric and volumetric analysis, Qualitative analysis: Identification of ions and functional groups, Instrumental methods: Atomic absorption spectroscopy, UV-Vis spectroscopy	06

VI	**Applications of Chemistry in Engineering:** Corrosion and its prevention techniques, Polymer chemistry and its applications, Environmental chemistry: Pollution control, wastewater treatment, Materials science: Properties and synthesis of materials	**05**
Text Books		
1.	T. L. Brown, H. E. LeMay Jr., B. E. Bursten, C. J. Murphy, P. M. Woodward, M. W. Stoltzfus, (2019), Chemistry: The Central Science, ISBN-978-0134988544, Pearson Publisher.	
2.	D. W. Oxtoby, H. P. Gillis, L. J. Butler., (2017), Principles of Modern Chemistry, ISBN: 978-1305079113, Cengage Learning Publisher.	
3.	D. A. Wauchope, (2004), Analytical Chemistry: Principles and Techniques, ISBN: 978-0201610995, Pearson Publisher.	
4.	B. H. Puri, L. R. Sharma and M. S. Prathama, (2001), Principles of Physical Chemistry, S. Chand and Company, New Delhi.	
5.	G. D. Christian, P. K. Dasgupta, K. A. Schug, (2013), Analytical Chemistry, 7th edition, ISBN: 9780470887578, John Wiley & Sons	
Reference Books		
1.	D. A. McQuarrie, J. D. Simon, (1997), Physical Chemistry: A Molecular Approach, ISBN: 978-1891389504, University Science Books.	
2.	G. L. Miessler, P. J. Fischer, D. A. Tarr, (2013), Inorganic Chemistry, ISBN: 978-0321811059, Pearson Publisher	
3.	D. C. Harris, (2015), Quantitative Chemical Analysis, ISBN: 978-1319154141, W. H. Freeman Publishing	
4.	P. Atkins & J. Paula, (2002), Atkins' Physical Chemistry, 7th Edition, Oxford University Press	
Useful web links		
1.	https://nptel.ac.in/courses/104103069	
2.	https://onlinecourses.nptel.ac.in/noc20_cy18/preview	
3.	https://onlinecourses.nptel.ac.in/noc22_ch23/preview	
4.	https://www.chemguide.co.uk/index.html#top	

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<tr><td>Year, Program, Semester</td><td colspan="8">S.Y. B. Tech (Chemical Engineering) , Part II, Semester III</td></tr>
<tr><td>Course Code</td><td colspan="8">BSC211</td></tr>
<tr><td>Course Category</td><td colspan="8">Basic Science Course</td></tr>
<tr><td>Course title</td><td colspan="8">Applied Chemistry-I (Physical, Inorganic & Analytical) (Practical)</td></tr>
<tr><td rowspan="2">Teaching Scheme and Credits</td><td>L</td><td>T</td><td>P</td><td colspan="3">Total Contact Hours</td><td colspan="2">Credits</td></tr>
<tr><td>-</td><td>-</td><td>02</td><td colspan="3">02</td><td colspan="2">01</td></tr>
<tr><td rowspan="2">Evaluation Scheme</td><td colspan="2">ISE</td><td>ESE</td><td>IOE</td><td>IPE</td><td>EOE</td><td>EPE</td><td>Total</td></tr>
<tr><td colspan="2">-</td><td>-</td><td>50</td><td>-</td><td>50</td><td>-</td><td>100</td></tr>
<tr><td>Pre-requisites(if any)</td><td colspan="8">BSC111, BSC121</td></tr>
<tr><td>Course Rationale</td><td colspan="8">This course is designed to provide students with physical, inorganic and analytical skills and techniques relevant to chemical engineering. The focus will be on hands-on experiments, data analysis, and the application of theoretical concepts to practical situations. The students will be able to understand and explain scientifically the various chemistry related problems in the industry/engineering and develop experimental skills for building technical competence.</td></tr>
<tr><td>Course Objectives</td><td colspan="8">The Course Teacher will ensure to
1. Develop practical skills in conducting experiments related to physical, inorganic, and analytical chemistry.
2. Reinforce theoretical concepts learned in lectures through hands-on laboratory experiences.
3. Enhance critical thinking and problem-solving skills in experimental design and data analysis.
4. Promote collaboration and teamwork through group-based laboratory activities.
5. Cultivate an appreciation for the role of experimentation in advancing scientific knowledge and solving real-world problems.</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">Upon completion of this course, student should be able to
1. Demonstrate proficiency in performing laboratory experiments in physical, inorganic, and analytical chemistry.
2. Acquire competence in using laboratory equipment, instruments, and software for data collection, analysis.
3. Demonstrate the ability to troubleshoot experimental issues, make observations, and draw logical conclusions based on experimental outcomes.
4. Collaborate effectively with peers in group-based laboratory activities, demonstrating teamwork, communication, and interpersonal skills.
5. Tackle on to safety protocols and ethical standards in a laboratory environment.</td></tr>
</table>

Course Outcome and Program Outcome Mapping

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO1	3	-	-	-	2	-	-	-	-	-	-	-
CO2	-	-	-	-	3	-	-	1	-	-	-	-
CO3	-	3	-	3	-	-	-	2	-	-	-	-
CO4	-	-	-	-	-	-	-	-	3	3	-	-
CO5	-	-	-	-	-	-	-	3	-	-	-	1

Level of Mapping as: Low 1, Moderate 2, High 3

General Instructions: Any 08 experiments to be performed from the list, any 02 experiments to be studied as demonstration.

Experiment No.	Experiment Title	Hours
1.	Determination of the concentration of an unknown acid or base solution using titration with a standardized solution.	**02**
2.	Determination of the partition coefficient of benzoic acid between benzene and water	**02**
3.	Investigation of constant for the adsorption of oxalic acid or Acetic acid from aqueous solution by activated charcoal and examine the validity of Freundlich and Langmuir isotherms	**02**
4.	Determination of the concentration of a specific ion in a sample through gravimetric analysis.	**02**
5.	Measurement of the pH of various solutions and prepare buffer solutions of desired pH.	**02**
6.	Study of the kinetics of a chemical reaction and determine the rate constant.	**02**
7.	Verification of Lambert-Beer's law by using copper sulphate solution using colorimeter.	**02**
8.	Study of the principle and demonstration of Gas chromatography.	**02**
9.	Separation and identification of the cations from the given mixture by paper chromatographic technique.	**02**
10.	Determination of amount of acetic acid in commercial vinegar using sodium hydroxide.	**02**

11.	Analysis of quality of water samples for various parameters such as pH, dissolved oxygen, and contaminants	**02**
12.	Preparation of a polymer and characterization of its properties.	**02**
13.	Determination of the concentration of an oxidizing or reducing agent using redox titration.	**02**
14.	Preparation of standard solution of sodium thiosulphate & to estimate copper from brass solution.	**02**
15.	Preparation of standard solution of potassium dichromate & to estimate Iron from ammonium sulphate using external indicator.	**02**
16.	Preparation of standard solution of potassium dichromate & to estimate Iron from ammonium sulphate using internal indicator.	**02**
Text Books/ Reference Books		
1.	J. F. Hall, (2006), Experimental Chemistry, ISBN: 978-0495014950, Cengage Learning.	
2.	J. R. Dean, A. M. Jones, D. Holmes, R. Reed, J. Weyers, (2009), Practical Skills in Chemistry, ISBN: 978-0273731184, Pearson.	
3.	J. R. Mohrig, D. Alberg, G. Hofmeister, P. F. Schatz, C. N. Hammond, (2013), Laboratory Techniques in Organic Chemistry, ISBN: 978-1464134227, W. H. Freeman.	
4.	D. Harvey, (2010), Modern Analytical Chemistry, ISBN: 978-0073402821, McGraw-Hill Education.	
5.	D. C. Harris, (2015), Quantitative Chemical Analysis, ISBN: 978-1319154141, W. H. Freeman.	
6.	P. T. Kissinger, W. R. Heineman, (1996), Laboratory Techniques in Electro-analytical Chemistry, ISBN: 978-0824792479, CRC Press.	
Useful Web links		
1.	https://www.rsc.org/learn-chemistry	
2.	https://www.chemguide.co.uk/	
3.	https://www.labster.com/	

<table>
<tr><td>Year, Program, Semester</td><td colspan="7">S.Y. B. Tech (Chemical Engineering) , Part II ,Semester III</td></tr>
<tr><td>Course Code</td><td colspan="7">BSC212</td></tr>
<tr><td>Course Category</td><td colspan="7">Basic Science Course</td></tr>
<tr><td>Course title</td><td colspan="7">Engineering Mathematics-III</td></tr>
<tr><td rowspan="2">Teaching Scheme and Credits</td><td>L</td><td>T</td><td>P</td><td colspan="2">Total Contact Hours</td><td colspan="2">Total Credits</td></tr>
<tr><td>03</td><td>-</td><td>-</td><td colspan="2">03</td><td colspan="2">03</td></tr>
<tr><td rowspan="2">Evaluation Scheme</td><td colspan="2">ISE</td><td>ESE</td><td>IOE</td><td>IPE</td><td>EOE</td><td>EPE</td><td>Total</td></tr>
<tr><td colspan="2">30</td><td>70</td><td>50</td><td>-</td><td>-</td><td>-</td><td>150</td></tr>
<tr><td>Pre-requisites(if any)</td><td colspan="7">BSC112, BSC122.</td></tr>
<tr><td>Course Rationale</td><td colspan="7">This course is about the basic mathematics that is fundamental and essential component in all streams of undergraduate studies in sciences and engineering. The course consists of topics in differential equations, partial differential equations, Laplace transform, it’s inverse and Vector calculus with applications to various engineering problems.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">The Course Teacher will
1. Discuss the fundamental concepts of Linear Differential Equations.
2. Describe the types of Partial Differential Equations.
3. Illustrate the methods of solving Partial Differential Equations such as wave equation, heat equation and Laplace equation.
4. State and explain the concepts of Laplace transforms.
5. Explain the concepts of inverse Laplace transforms.
6. Outline Vector Calculus and its applications.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">Upon completion of this course, student should be able to
1. Apply linear differential equations to solve numerical related to Chemical Engineering.
2. Apply partial differential equations to solve numerical related to Chemical Engineering.
3. Solve Partial Differential Equations such as wave equation, heat equation and Laplace equation.
4. Apply Laplace transform to solve differential equation involved in heat transfer and Process Control.
5. Solve inverse Laplace transform.
6. Perform vector differentiation & integration, analyze the vector fields and apply to fluid flow problems.</td></tr>
</table>

Course Outcome and Program Outcome Mapping

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO1	3	3	2	2	2	-	-	-	-	-	-	-
CO2	3	3	2	2	2	-	-	-	-	-	-	-
CO3	3	3	2	2	2	-	-	-	-	-	-	-
CO4	3	3	2	2	2	-	-	-	-	-	-	-
CO5	3	3	2	2	2	-	-	-	-	-	-	-
CO6	3	3	1	1	1	-	-	-	-	-	-	-

Level of Mapping as: Low 1, Moderate 2, High 3

Unit No.	Course Content	Hours
I	**Linear Differential Equations:** Linear Differential Equations with constant coefficients, Homogeneous Linear differential equations	**05**
II	**Partial Differential Equations:** Four standard forms of partial differential equations of first order.	**06**
III	**Application of Partial differential Equations:** Wave Equation, One dimensional heat flow equation, two-dimensional heat flow, Laplace equation (Steady State).	**07**
IV	**Laplace Transform:** Definition, transforms of elementary functions, Properties of Laplace transforms, transforms of derivatives, transforms of integral, transforms of periodic function	**07**
V	**Inverse Laplace Transforms:** Inverse Laplace transforms by using partial fractions, Convolution theorem, Applications to solve linear differential equations with constant coefficients (Initial value problems) using transform method, evolution of definite integrals.	**07**
VI	**Vector Calculus:** Differentiation of vectors, Velocity and acceleration, Gradient of scalar point function, Directional derivative, Divergence of vector point function, Curl of a vector point function, Irrotational and Solenoid vector fields. The line integral, surface integral, volume integral, Gauss Divergence theorem, Stoke's theorem, Green's theorem (without proof).	**07**

	Suggested list of Tutorials and Assignments- 1. To find solution of LDE with constant coefficients 2. Partial Differential Equations 3. Applications of PDE 4. Laplace Transform 5. Inverse Laplace transform 6. Vector differentiation 7. Vector Integration **General Instructions:** 1. Batch wise tutorials are to be conducted. The number of students per batch should be as per the practical batches 2. Each Student has to write at least 6 assignments on entire syllabus.	

Text Books	
1.	Dr.B. S. Grewal, "Higher Engineering Mathematics", Khanna Publishers, New Delhi.
2.	J. N. Wartikar & P. N. Wartikar, 'A text book of Applied Mathematics: Vol. I, II and III', Vidyarthi Griha Prakashan, Pune.
3.	Ramana, B.V., (2017), "Higher Engineering Mathematics", McGraw Hill Education India.
4.	H. K. Das, "Advanced Engineering Mathematics", S. Chand Publication.
Reference Books	
1.	Shanti Narayan, "Differential Calculus" S. Chand and company, New Delhi.
2.	Wylie, C.R. Advanced Engineering Mathematics", McGraw Hill Publication, New Delhi.
3.	Sastry, S. S. "Engineering Mathematics (Volume-I)", Prentice Hall Publication, New Delhi.
4.	M. D. Greenberg, "Advanced Engineering Mathematics", Pearson Education.
5.	Kreyszig, Erwin, (2015), Advanced Engineering Mathematic, 10th Edition, Wiley India Pvt. Ltd.
Useful web links	
1.	https://nptel.ac.in/courses/111105121
2.	https://nptel.ac.in/courses/111106100
3.	https://nptel.ac.in/courses/111105134
4.	https://nptel.ac.in/courses/111105167

<table>
<tr><td>Year, Program, Semester</td><td colspan="7">S.Y. B. Tech (Chemical Engineering) ,Part II ,Semester III</td></tr>
<tr><td>Course Code</td><td colspan="7">PCC 211</td></tr>
<tr><td>Course Category</td><td colspan="7">Professional Core Courses</td></tr>
<tr><td>Course title</td><td colspan="7">Fluid Flow Operations (Theory)</td></tr>
<tr><td rowspan="2">Teaching Scheme and Credits</td><td>L</td><td>T</td><td>P</td><td colspan="2">Total Contact Hours</td><td colspan="2">Total Credits</td></tr>
<tr><td>03</td><td>01</td><td>-</td><td colspan="2">04</td><td colspan="2">04</td></tr>
<tr><td rowspan="2">Evaluation Scheme</td><td colspan="2">ISE</td><td>ESE</td><td>IOE</td><td>IPE</td><td>EOE</td><td>EPE</td><td>Total</td></tr>
<tr><td colspan="2">30</td><td>70</td><td>-</td><td>-</td><td>-</td><td>-</td><td>100</td></tr>
<tr><td>Pre-requisites(if any)</td><td colspan="7">BSC 111, BSC 112, BSC 122 and Physical Chemistry of Higher Secondary School Level</td></tr>
<tr><td>Course Rationale</td><td colspan="7">This course will provide the student with a basic understanding of fluid properties, fluid statics, fluid dynamics, and fluid flow. The flow of an incompressible fluid in pressure systems constitutes the major portion of this course. It introduces students to the mathematical description of fluid flows and the solution of some important flow problems.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">The Course Teacher will
1. Explain basic concepts of Fluid Statics and the allied topics.
2. Discuss basic laws that explain Fluid Flow systems.
3. Describe different equations concerning internal and external incompressible viscous flow.
4. Classify different flow measuring devices & illustrate related equations.
5. Compare fluidization systems and outline fluid conveying systems.
6. Categorize fluid moving devices and distinguish between those.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">Upon completion of this course, student should be able to
1. Use basics of Fluid Statics and other topics to solve problems.
2. Derive the basic laws pertaining to Fluid Flow systems.
3. Evaluate pressure drop, power requirements etc. for single phase flow in pipes.
4. Identify flow measuring devices and use the same for flow estimation.
5. Choose fluidization and conveying systems for various applications.
6. Distinguish between fluid moving devices & select the right one for a said purpose.</td></tr>
</table>

Course Outcome and Program Outcome Mapping

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	-	-	2	-	-	-	-	-	-	-	-
CO 2	2	2	-	-	-	-	-	-	-	-	-	-
CO 3	3	3	-	-	-	-	-	-	-	-	-	-
CO 4	3	3	-	-	-	1	-	-	-	-	-	-
CO 5	3	3	-	-	-	-	-	-	-	-	-	-
CO 6	3	2	-	-	-	-	-	-	-	-	-	1

Level of Mapping as: Low 1, Moderate 2, High 3

Unit No.	Course Content	Hours
I	**Fluid Statics:** Basic Equation of a fluid statics, pressure variations in a static field. Pressure measuring devices manometer, U-tube, inclined tube, Forced on submerged bodies (Straight and inclined), Centre of pressure.	**05**
II	**Basic equations in integral form:** Basic laws for a system, relation of system derivatives to the control volume formulation, conservation of mass, continuity equation, momentum balance equation, Introduction to Navier Stoke's and Euler's Equation, Introduction to rotational and irrotational flow, momentum correction factor.	**06**
III	**Internal incompressible viscous flow:** Introduction, flow of incompressible fluid in circular pipe, laminar flow for Newtonian fluid, Hagen-Poiseuille equation, introduction to turbulent flow in a pipe-Prandtl mixing length, energy consideration in pipe flow, relation between average and maximum velocity, Bernoulli's equation–kinetic energy correction factor, head loss, friction factor-Fanning and Darcy, Moody diagram, major and minor losses, Pipe fittings and valves, schedule no, equivalent diameter. Two-Phase Flow in Pipes: Introduction to Two-Phase Flow, Types of Two-Phase Flows, Classification based on fluid properties (e.g., gas-liquid, liquid-liquid). Overview of flow regimes (e.g., bubbly flow, slug flow, annular flow). Flow Patterns and Transitions, Factors influencing transitions between flow regimes. Pressure Drop and Void Fraction, Calculation methods for pressure drop in two-phase flow.	**09**
IV	**Flow measurement:** Introduction; general equation for internal flow meters; Orifice meter; Venturi meter; Weirs, concept of area meters: rotameter; Local velocity measurement: Pitot tube. Hot wire anemometer, mass flow meter. Resistance of immersed bodies: Introduction; concept of drag and lift; variation of drag coefficient with Reynolds number; stream-lined body and bluff body; packed bed; concept of sphericity; Ergun equation, modified friction factor.	**07**
V	**Fluidization:** Introduction; different types of fluidizations; minimum fluidization velocity; governing equation; pneumatic conveying and other industrial uses.	**04**

VI	**Fluid flow devices:** Introduction; Basic classification of pumps: Non-Mechanical Pumps-acid egg, steam jet ejector, air lift pump, Mechanical pump: Centrifugal pumps- cavitation, NPSH, Positive displacement pumps (rotary, piston, plunger, diaphragm pumps); pump specification; basic characteristics curves for centrifugal pumps; fan, blower and compressor.	**08**
Text Books		
1.	McCabe W L, Smith J C, Harriot P, (1993), 'Unit Operations of Chemical Engineering',7th Edition, McGraw Hill.	
2.	V. Gupta & S.K. Gupta, (2012), 'Fluid Mechanics & Application', 3rd Edition, New Age International Pvt. Ltd.	
3.	Streeter V. L, E.Benjamin Wylie, (1985), 'Fluid Mechanics' 8th Edition, McGraw Hill	
4.	R.K. Rajput, 'Fluid Mechanics and Hydraulic Machines', S. Chand & Co	
Reference Books		
1.	Bird R.B., Stewart W.E., Lightfoot, (1960), 'Transport Phenomena', 2nd Edition, John Wiley & Sons.	
2.	Richardson J.E. and Coulson, (1977), 'Chemical Engineering', Volume1, 5th Edition, Butterworth-Heinemann.	
3.	F. W. White,(2022), 'Fluid Mechanics', 9th Edition, McGraw Hill	
4.	Cl Kleinstreuer, (2003), 'Two-Phase Flow-Theory and Applications'1stedition, New York.	

<table>
<tr><td>Year, Program, Semester</td><td colspan="7">S.Y. B. Tech(Chemical Engineering) , Part II, Semester III</td></tr>
<tr><td>Course Code</td><td colspan="7">PCC 211</td></tr>
<tr><td>Course Category</td><td colspan="7">Professional Core Courses</td></tr>
<tr><td>Course title</td><td colspan="7">Fluid Flow Operations (Practical)</td></tr>
<tr><td rowspan="2">Teaching Scheme and Credits</td><td>L</td><td>T</td><td>P</td><td colspan="2">Total Contact Hours</td><td colspan="2">Credits</td></tr>
<tr><td>-</td><td>-</td><td>02</td><td colspan="2">02</td><td colspan="2">01</td></tr>
<tr><td rowspan="2">Evaluation Scheme</td><td colspan="2">ISE</td><td>ESE</td><td>IOE</td><td>IPE</td><td>EOE</td><td>EPE</td><td>Total</td></tr>
<tr><td colspan="2">-</td><td>-</td><td>-</td><td>50</td><td>-</td><td>50</td><td>100</td></tr>
<tr><td>Pre-requisites(if any)</td><td colspan="7">BSC 111, BSC 112, BSC 122 and Physical Chemistry of the Higher Secondary school level.</td></tr>
<tr><td>Course Rationale</td><td colspan="7">Through this course the students gain a hands-on experience in fluid mechanics, adequate knowledge on the fundamental concepts of measurement techniques and numerical analysis, experimental data analysis, technical report writing and work in teams.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">The Course Teacher will
1. Demonstrate different experimental verifications of theoretical concepts in Fluid Mechanics.
2. Explain procedures to calculate the Pressure drop in straight pipes, fluidized bed and packed bed.
3. Organize experiments that relate to fluid flow handling like volumetric flow rate measurement, fluid pressure measurement etc.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">Upon completion of this course, student should be able to
1. Experimentally verify various laws pertaining fluid mechanics.
2. Calculate the Pressure drop in straight pipes, fluidized bed and packed bed.
3. Acquaint with fluid flow handling and calibrate fluid flow and pressure measuring devices.</td></tr>
</table>

Course Outcome and Program Outcome Mapping

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO1	3	-	3	-	-	-	-	-	1	-	-	-
CO2	3	3	-	-	-	-	-	-	-	-	-	-
CO3	3	1	-	1	-	-	-	-	1	-	-	-

Level of Mapping as: Low 1, Moderate 2, High 3

General Instructions: Any 8 experiments to be performed from the list, any 2 experiments to be studied as demonstration.

Experiment No.	Experiment Title/Objective	Hours
1.	To determine the different types of flow Patterns by Reynolds's experiment.	**02**
2.	To determine the Coefficient of discharge through Orifice meter.	**02**
3.	To determine the Coefficient of discharge through Venturimeter.	**02**
4.	Verification of Bernoulli's theorem.	**02**
5.	To determine the Coefficient of discharge by using Pitot tube.	**02**
6.	To determine losses in different Pipe fittings.	**02**
7.	To determine the Friction factor for the different pipes.	**02**
8.	To study pressure measurement procedure and related instruments/devices.	**02**
9.	To determine the Cd, Cv, Cc by using Orifice meter Apparatus.	**02**
10.	Demonstration Flow through fluidized bed.	**02**
11.	Demonstration of Centrifugal pump.	**02**
12.	Demonstration of Reciprocating pump.	**02**
13.	Demonstration of Rotameter.	**02**

Suggested Text Books/ Reference Books/Manual	
1.	Sarbjit Singh, 2009, 'Experiments in Fluid Mechanics', 2nd Edition PHI Learning Pvt. Ltd.
2.	R V Raikar, 2012, 'Laboratory Manual Hydraulics and Hydraulic Machines', 2nd Edition, PHI Learning Pvt. Ltd.
3.	Institute's Laboratory Course Manual and equipment wise Standard Operating Procedure to follow.

<table>
<tr><td>Year, Program, Semester</td><td colspan="8">S.Y. B. Tech (Chemical Engineering) , Part II ,Semester III</td></tr>
<tr><td>Course Code</td><td colspan="8">PCC 212</td></tr>
<tr><td>Course Category</td><td colspan="8">Professional Core Courses</td></tr>
<tr><td>Course title</td><td colspan="8">Chemical Engineering Thermodynamics</td></tr>
<tr><td rowspan="2">Teaching Scheme and Credits</td><td>L</td><td>T</td><td>P</td><td colspan="4">Total Contact Hours</td><td>Total Credits</td></tr>
<tr><td>03</td><td>01</td><td>-</td><td colspan="4">04</td><td>04</td></tr>
<tr><td rowspan="2">Evaluation Scheme</td><td>ISE</td><td colspan="2">ESE</td><td>IOE</td><td>IPE</td><td>EOE</td><td>EPE</td><td>Total</td></tr>
<tr><td>30</td><td colspan="2">70</td><td>-</td><td>-</td><td>-</td><td>-</td><td>100</td></tr>
<tr><td>Pre-requisites (if any)</td><td colspan="8">BSC111, BSC112, BSC121, BSC122</td></tr>
<tr><td>Course Rationale</td><td colspan="8">This is a core subject of Chemical Engineering and is essential for understanding basic concepts, First and Second Law of Thermodynamics, thermodynamic properties of fluid and performance of thermal systems used in industry. This course introduces the basic thermodynamics concepts of multiphase equilibrium in pure and multi-component systems.</td></tr>
<tr><td>Course Objectives</td><td colspan="8">The Course Teacher will
1. Explain basic concepts and laws of thermodynamics, including energy, entropy, and the laws of thermodynamic equilibrium.
2. Ensure that students will gain proficiency in applying thermodynamic principles to analyze and solve engineering problems related to energy conversion and process design.
3. Ensure that the students will learn the fundamentals of thermodynamic properties such as enthalpy, entropy, and Gibbs free energy, and their significance in engineering applications.
4. Make the students understand the principles of phase equilibrium and apply thermodynamics to analyze phase transitions and separation processes.
5. Ensure that the students will learn about chemical reaction thermodynamics and its relevance to chemical reaction equilibrium and kinetics.
6. Develop among the students, problem-solving skills through the application of thermodynamic principles to real-world engineering problems.</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">Upon completion of this course, student should be able to
1. Apply the laws of thermodynamics to analyze and solve engineering problems involving energy conversion and heat transfer.
2. Calculate and interpret thermodynamic properties such as enthalpy, entropy, and Gibbs free energy for engineering</td></tr>
</table>

	applications. 3. Analyze the behavior of pure substances and mixtures using phase equilibrium and thermodynamic property models. 4. Apply chemical reaction thermodynamics to analyze reaction equilibrium and predict reaction outcomes. 5. Use thermodynamic software and computational tools to solve complex engineering problems. 6. Communicate effectively and present solutions to thermodynamics problems both orally and in writing.

Course Outcome and Program Outcome Mapping

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3	-	-	3	-	-	-	3	-	-	-
CO 2	3	3	3	-	3	-	-	-	3	-	-	-
CO 3	3	3	-	3	3	-	-	-	3	-	-	-
CO 4	3	3	-	3	3	-	-	-	3	-	-	-
CO 5	3	3	-	-	3	-	-	-	3	-	-	-
CO 6	-	-	-	-	-	3	3	-	-	3	2	2

Level of Mapping as: Low 1, Moderate 2, High 3

Unit No.	Course Content	Hours
I	**Basic Concepts & P-V-T Behavior, First and Second Law of Thermodynamics :** Properties: Extensive/Intensive, pendent/Independent, P-V-T behavior of pure substances,First Law of Thermodynamics: Energy balance for closed systems, Reversible & irreversible processes, Closed systems, Open systems, Internal energy, Gibbs phase rule, Equilibrium, Equations of State: Virial equation of state, Equations for Process Calculations for Ideal gases , Application of Virial equations, Cubic equations of state, van der Waals equation of state, Principle of corresponding states. Statement of second law, Heat Engines, Carnot's Theorem, Entropy, and Entropy changes of an Ideal Gas, Mathematical statement of second law, Thermodynamic Cycles: Carnot and Rankine Cycles.	**10**
II	**Thermodynamic Properties and Relationships:** Thermodynamic Properties and Relationships: Fundamental properties, Maxwell relations and cyclic rules	**05**
III	**Phase Equilibria:** Phase equilibrium criteria for pure substances, Application: Clapeyron equations, Partial molar properties, Gibbs-Duhem equations, Property	**08**

	changes of mixing, Determination of partial molar properties, Multicomponent phase equilibria, Fugacity: definition, Fugacity in vapor phase.	
IV	**Fugacity & Activity coefficients:** Fugacity in liquid phase: Ideal Solutions (Lewis/Randall) and Henry's Law, Activity coefficients, Excess Gibbs energy, Models for binary activity coefficients: Margules, Van Laar, Wilson, NTRL.	**05**
V	**Vapor-liquid equilibrium:** Vapor-liquid equilibrium: Raoult's Law, Bubble-point and dew-point calculations, Non-ideal liquids and azeotropes, Applications for flash and distillation process, Activity coefficients from VLE data, Solubility of gases in liquids, Liquid-liquid equilibrium, Vapor-liquid-liquid equilibrium, Solid-liquid and solid-solid equilibrium.	**06**
VI	**Chemical Reaction Equilibria:** Equilibrium for single reaction, Equilibrium constants and their temperature dependence, Heterogeneous reaction, Multiple reactions, Gibbs phase rule, Reaction equilibria via minimization of Gibbs energy**.**	**05**
Text Books		
1.	Smith, van Ness, Abbott, (2012), Introduction to Chemical Engineering Thermodynamics , 7th edition, McGraw-Hill Companies, Inc., Series in Chemical Engineering.	
Reference Books		
1.	B.G. Kyle, (2000), Perry's Chemical Engineers Handbook, 7th edition, McGraw, Hill, USA	
2.	Stanley I. Sandler, (2007), Chemical, Biochemical and Engineering Thermodynamics, 4th edition, Wiley India Pvt. Ltd.,	
Useful web links		
1.	https://archive.nptel.ac.in/courses/103/103/103103144/	

<table>
<tr><td>Year, Program, Semester</td><td colspan="7">S.Y. B. Tech(Chemical Engineering), Part II, Semester III</td></tr>
<tr><td>Course Code</td><td colspan="7">ESC211</td></tr>
<tr><td>Course Category</td><td colspan="7">Engineering Science Course</td></tr>
<tr><td>Course title</td><td colspan="7">Material Science & Engineering</td></tr>
<tr><td rowspan="2">Teaching Scheme and Credits</td><td>L</td><td>T</td><td>P</td><td colspan="2">Total Contact Hours</td><td colspan="2">Credits</td></tr>
<tr><td>03</td><td>-</td><td></td><td colspan="2">03</td><td colspan="2">03</td></tr>
<tr><td rowspan="2">Evaluation Scheme</td><td colspan="2">ISE</td><td>ESE</td><td>IOE</td><td>IPE</td><td>EOE</td><td>EPE</td><td>Total</td></tr>
<tr><td colspan="2">30</td><td>70</td><td>-</td><td>-</td><td>-</td><td>-</td><td>100</td></tr>
<tr><td>Pre-requisites (if any)</td><td colspan="7">BS-11A2 and BS-12A2</td></tr>
<tr><td>Course Rationale</td><td colspan="7">The course is important both from a scientific perspective as well as for applications field. Materials are of the utmost importance for engineers (or other applied fields), especially for Chemical Engineers because usage of the appropriate materials is crucial when designing various systems.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">The Course Teacher will
1. Summarize need to know about properties of materials and their respective applications
2. Explain magnetic and electrical materials and their properties
3. Illustrate characterization and processing of materials.
4. Discuss the principles of material testing and characterization and to apply them for various engineering applications.
5. Elaborate basic concepts and properties of Nano materials.
6. Discuss various design aspects and criteria of material selection.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">Upon completion of this course, student should be able to
1. Identify materials and describe their properties.
2. Understand the electrical and magnetic properties of important Engineering Material.
3. Recall to the processing and performance w.r.t. economic evaluation of material.
4. Explain structure and properties of different ceramic materials.
5. Understand basic properties of Nano materials.
6. Use various criteria for material selection in process and equipment design and drawing.</td></tr>
</table>

Course Outcome and Program Outcome Mapping

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO1	3	3	2	2	2	-	1	2	3	-	-	-
CO2	3	2	2	-	2	-	1	2	2	-	-	-
CO3	3	3	2	2	2	-	-	3	3	-	-	-
CO4	3	3	2	2	2	-	-	2	3	-	-	-
CO5	3	3	2	2	2	-	1	2	3	-	-	-
CO6	3	3	3	2	2	-	1	2	3	-	2	2

Level of Mapping as: Low 1, Moderate 2, High 3

Unit No.	Course Content	Hours
I	**Introduction:** Introduction to materials and their principle properties, Structure property relationships in Materials. Introduction to determination of mechanical properties of materials ASTM methods.	**07**
II	**Engineering Materials:** Basic principles in selection of materials for fabrication and erection of chemical plant. Testing of materials, destructive and non-destructive tests, structure of atom and chemical bonds, crystal structures and their influence on material properties, Deformation and slip processes.	**07**
III	**Processing of materials:** Introduction to materials processing; Polymer processing, Compounding of plastics and rubber, Molding techniques, Calendaring, Thermo forming, casting, Sintering, Dip coating; Manufacturing process of fibers.	**07**
IV	**Typical Engineering Materials**: Definition of ceramics and glasses; interaction between structure, processing, and Mechanical, electrical and thermal properties of ceramic phase; Applications of ceramic and glass materials; Crystalline and no crystalline ceramics, silicates, refractories, clays, cements, glass vitreous silica, and borosilicate. Ceramic Organic materials, Organic protective coatings.	**07**
V	**Electrical and magnetic materials:** Factors affecting the resistivity of conductors, properties of materials such as Ag, Cu, Al, Ni-chrome and Ca as dielectric characteristics, insulating materials such as mineral oil, PVC, Mica fibers, glass and asbestos, Magnetization, soft and hard magnetic materials such as a silicon iron, Alnico types alloys and ferrites.	**06**
VI	**Nano materials:** Classification and application of Nano Materials – Fullerenes, carbon Nano tubes. Nano particles – silver Nano particles. Applications of Nano materials in Chemical Industry.	**05**
Text Books		
1.	R. Abbaschian, R.E. Reed-Hill, 'Physical Metallurgy Principles', (2009),4th ed., Cengage Learning,	

2.	T.A. Ostwald, (1998), 'Polymer Processing Fundamentals', Hanser Publications.
3.	S. Kalpakjian, S.R. Schmid,(2009), 'Manufacturing Engineering and Technology', 6th ed., Pearson,
Reference Books	
1.	R.B. Gupta, (2018), 'Material science'.
2.	V.K. Manchanda, (1996), 'A Text Book of Material Science'.
3.	V. Raghavan, (2015), 'Material Science and Engineering', PHI Learning Pvt. Ltd. New Delhi.
4.	Punmia B.C., (1990) 'Strength of Materials and Mechanics of Structure'- Vol. I- Standard Publications, Delhi.
Reference Books	
1.	https://archive.nptel.ac.in/courses/113/102/113102080/

Year, Program, Semester	S.Y. B.Tech Chemical Engineering) ,Part II ,Semester III							
Course Code	AEC211							
Course Category	Ability Enhancement Courses							
Course title	**Soft Skills Development**							
Teaching Scheme and Credits	**L**	**T**	**P**	**Total Contact Hours**		**Credits**		
	01	-	**-**	01		01		
Evaluation Scheme	**ISE**	**ESE**	**IOE**	**IPE**	**EOE**	**EPE**	**Total**	
	-	-	50	**-**	-	-	50	
Pre-requisites (if any)	H. S. C. Level English language competency**.**							
Course Rationale	In today's competitive professional landscape, technical skills alone are insufficient. Soft skills such as communication, teamwork, problem-solving, and adaptability are essential for engineering graduates to thrive in their careers. This course aims to equip students with the necessary soft skills to complement their technical expertise and enhance their employability and success in the workplace.							
Course Objectives	The Course Teacher will 1. Help to enhance communication, teamwork, problem-solving skills. 2. Help to foster adaptability and resilience in engineering contexts.							
Course Outcomes	Upon completion of this course, student should be able to 1. Be proficient in oral and written communication. 2. Be effective as regards teamwork and collaboration skills. 3. Apply critical thinking to industrial problems. 4. Demonstrate adaptability and resilience in profession.							

Course Outcome and Program Outcome Mapping

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO1	-	-	-	-	-	-	-	-	3	3	-	-
CO2	-	-	-	-	-	-	-	-	3	-	-	-
CO3	-	3	-	-	-	-	-	-	-	-	-	-
CO4	-	-	-	-	-	-	-	-	-	-	-	2

Level of Mapping as: Low 1, Moderate 2, High 3

Unit No.	Course Content	Hours
I.	**Written communication:** • Email Writing • Technical Report	03
II.	**Oral Communication:** • Presentation Skills	02
III.	**Soft Skills:** • Importance of Soft Skills • Overview of Various Soft Skills	02
IV.	**Team Spirit & Leadership Ability:** • Understanding team dynamics and roles • Building trust and rapport within team	02
V.	**Assessment:** • Discussion on incorporating soft skills development into daily practice • Case Studies or Role-Play	05

Course Assessment Method

For the internal assessment of the course, with a total evaluation is of 50 marks. Combination of different evaluation methods can be utilized to ensure comprehensive assessment of the students' performance. Following Evaluation Components are suggested:

1. **Quizzes/Tests (10 marks)**
   Periodic quizzes or tests to evaluate students' understanding of key concepts and their ability to apply them.
2. **Activity 1 (10 marks)**
   Group activity focusing application of creative thinking and teamwork; designed to assess both individual and group performance
3. **Activity 2 (20 marks)**
   Group activity focusing application of creative thinking and teamwork; designed to assess both individual and group performance.
4. **Classroom Participation and Engagement (10 marks)**
   Demonstrating engagement with course material and Active participation in class discussions, group activities and question-answer sessions.

Reference Books	
1.	Sharma R. & Krishna Mohan (2017), *Business Correspondence and Report Writing*, McGraw Hill Education.
2.	P. D. Chaturvedi & Mukesh Chaturvedi (2013), Business Communication: Skills, Concepts & Applications, Pearson Publications, New Delhi, 3rd Edition, Seventh Impression
3.	K. K. Sinha (2006), Business Communication, 2nd Edition (Reprint), Galgotia Publishing, New Delhi.
4.	Khera, S. (1998). "You Can Win: A Step-by-Step Tool for Top Achievers." New Delhi: Macmillan Publishers India.
5.	Covey, S. R. (2004). "The 7 Habits of Highly Effective People." New York: Free Press.
6.	Carnegie, D. (2009). "How to Win Friends and Influence People." New York: Pocket Books.
7.	Bradberry, T., & Greaves, J. (2009). "Emotional Intelligence 2.0." San Diego, CA: TalentSmart.
8.	Dweck, C. S. (2006). "Mindset: The New Psychology of Success." New York: Ballantine Books.

Year, Program, Semester	S.Y. B. Tech (Chemical Engineering), Part II, Semester III						
Course Code	PBL211						
Course Category	Project Based Learning						
Course title	**Mini Project I & Industrial Visit**						
Teaching Scheme and Credits	**L**	**T**	**P**	**Total Contact Hours**		**Total Credits**	
	-	01	-	01		01	
Evaluation Scheme	**ISE**	**ESE**	**IOE**	**IPE**	**EOE**	**EPE**	**Total**
	-	-	50	-	-	-	50
Pre-requisites(if any)	Thorough revision of all the courses studied till Semester III with a vigor to undertake small survey type of project work.						
Course Rationale	This course aims to provide students with practical exposure and hands-on experience in real-world industrial settings, fostering a deeper understanding of theoretical concepts through application. By engaging in mini projects and industrial visits, students will develop essential skills such as problem-solving, teamwork, and communication, preparing them for future challenges in the professional arena. The course aligns with NEP 2020's emphasis on experiential learning and Outcome Based Education (OBE) principles, ensuring graduates are equipped with the competencies needed to excel in the dynamic global workforce.						
Course Objectives	The course teacher will 1. Facilitate application of theoretical knowledge. 2. Guide the students about enhancement of practical skills. 3. Explain about development of industry-relevant competencies.						
Course Outcomes	Upon completion of this course, student should be able to 1. Demonstrate application of theoretical concepts with instructor guidance. 2. Collaborate effectively in instructor-led team-based projects. 3. Communicate findings and insights professionally under instructor supervision.						

Course Outcome and Program Outcome Mapping

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	2	-	-	2	-	-	-	2	-	-	-
CO 2	-	-	3	-	-	-	-	-	3	-	2	1
CO 3	-	-	-	-	-	-	-	-	-	3	-	2

Level of Mapping as: Low 1, Moderate 2, High 3

Course Content

Mini Project I and Industrial Visit is a dynamic course designed to bridge the gap between classroom learning and real-world application. Throughout the semester, all students will engage themselves in a series of mini projects that challenge them to apply theoretical concepts learned in previous courses to solve practical problems. These projects, conducted in small groups, will cover a range of topics relevant to their field of study, allowing students to explore different facets of their discipline and develop versatile skill sets.

Complementing the mini projects, students will participate in an industrial visit to domain relevant organizations in nearby regions, providing first hand exposure to industry operations, practices, and challenges. These visits will offer valuable insights into the application of theoretical knowledge in real-world settings, helping students understand the relevance and implications of their academic studies.

The course structure is carefully crafted to align with NEP 2020 and Outcome Based Education principles, emphasizing experiential learning, competency development, and holistic skill enhancement. Through active participation in mini projects and industrial visits, students will not only deepen their understanding of academic concepts but also cultivate essential soft skills such as teamwork, problem-solving, and effective communication.

Each week, students will dedicate one hour to course activities, including project discussions, progress updates, and preparation for industrial visits. Faculty guidance and mentorship will be provided to support students throughout their project work and industrial experiences, ensuring they maximize their learning outcomes and derive meaningful insights from their engagements.

By the end of the semester, students will emerge with a comprehensive understanding of how theoretical knowledge translates into practical applications within the industry, equipping them with the competencies and confidence to thrive in their future careers.

Course Assessment Method

The course evaluation will be at the course teacher end. The teachers will follow the instructions as below:

Evaluation Format: The evaluation may be conducted using a combination of assessment methods, including:

- Rubric-based assessment for mini projects and industrial visit reports.
- Peer evaluation for team-based projects.
- Written exams or quizzes to assess theoretical knowledge.
- Instructor-led discussions or presentations to evaluate communication skills and critical thinking.
- Overall course grading based on a weighted average of individual assessments and participation.

The evaluation format should be transparent, fair, and aligned with the course objectives and outcomes. Regular feedback and communication with students will ensure that the evaluation process remains supportive of their learning journey.

Reference Books	
1.	Ray, M. S., (1998), Chemical Engineering Design Project: A Case Study Approach (2nd ed.), CRC Press.
2.	Turton, R., Bailie, R.C., Whiting, W.B., Shaeiwitz, J.A., & Bhattacharyya, D., (2013), Chemical Engineering Design Project: A Case Study Approach (2nd ed.), Prentice Hall.
3.	Goyal, M., & Choudhary, S.K., (2016), Industrial Visits and Study in Chemical Process Industries, IK International Publishing House Pvt. Ltd.
Useful web links/ U-Tube Links	
1.	https://youtu.be/C9Q0HCGa_8I?si=rzIo0XB75vWGtdS1
2.	The students can search on u-tube for the following key words: 1. “Chemical Engineering Mini Projects" 2. "Chemical Engineering Industrial Visits" 3. "Hands-on Projects for Chemical Engineers" 4. "Industrial Visits in Chemical Process Industries"

Year, Program, Semester	S.Y. B.Tech (Chemical Engineering) , Part II, Semester III				
Course Code	HSMEC 211				
Course Category	Humanities, Social Sciences, Management, Environment				
Course title	**Environmental Studies**				
Teaching Scheme and Credits	**L**	**T**	**P**	**Total Contact Hours**	**Total Credits**
	02	-	-	02	00
Evaluation Scheme	SEE: 70 Marks + IOE: 30 Marks, evaluation only at Even Semester End.				
Pre-requisites (if any)	BSC111, BSC121				
Course Rationale	The Course is all about learning the way we should live and how we can develop sustainable strategies to protect the environment. It helps individuals to develop an understanding of living and physical environment and how to resolve challenging environmental issues affecting nature.				
Course Objectives	The Course Teacher will 1. Introduce students to the fundamental concepts and principles of environmental science. 2. Describe the components of various ecosystems and their interrelationships. 3. Classify different types of natural resources and assess their availability and distribution. 4. Define biodiversity and its significance to ecosystem functioning and human well-being.				
Course Outcomes	Upon completion of this course, student should be able to 1. Define key terms and concepts related to environmental science. 2. Analyse ecosystem services and their importance to human well-being. 3. Identify various types of natural resources and their significance. 4. Describe the levels and patterns of biodiversity and their importance.				

Course Outcome and Program Outcome Mapping

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	2	-	-	-	-	3	3	-	-	-	-
CO 2	-	3	3	-	-	-	3	3	3	2	-	-
CO 3	-	2	3	-	-	-	3	3	3	3	-	-
CO 4	-	2	-	-	-	-	3	3	3	3	-	-

Level of Mapping as: Low 1, Moderate 2, High 3

Unit No.	Course Content	Hours
I.	**Nature of Environmental Science:** Definition, scope and importance. Multidisciplinary nature of environmental studies Need for public awareness. Introduction to sustainable development: Sustainable Development Goals (SDGs) - targets and indicators, challenges and strategies for SDGs.	04
II.	**Ecosystem:** Concept of an ecosystem, Structure and function of an ecosystem, Producers, consumers and decomposers, Energy flow in the ecosystem, Ecological succession. Food chains, food webs and ecological pyramids, Introduction, types, characteristics features, structure and function of the Following ecosystem: - a) Forest ecosystem, b) Grassland ecosystem, c) Desert ecosystem, d) Aquatic ecosystems (ponds, streams, lakes, rivers, oceans, estuaries) Degradation of ecosystems and its impacts.	06
III	**Natural Resources and Associated Problems:** Overview of natural resources: Definition of resource; Classification of natural resources- biotic and abiotic, renewable and non-renewable. a) Forest resources: Use and over-exploitation, deforestation, dams and their effects on forests and tribal people. b) Water resources: Use and over-utilization of surface and ground water, floods, drought, conflicts over water, dams-benefits and problems. Water scarcity and stress; Conflicts over water. c) Soil and Mineral resources: Soil as resource and its degradation, Usage and exploitation, Environmental effects of extracting and using mineral resources, Wasteland reclamation, d) Energy resources: Growing energy needs, renewable and non- renewable energy resources, use of alternate energy sources. Solar energy, Biomass energy, Nuclear energy, e) Role of Indian traditions and culture in conservation of the environment.	08
IV	**Biodiversity and its conservation:** Introduction- Definition: genetic, species and ecosystem diversity, Bio-geographical classification of India, Value of biodiversity: consumptive use, productive use, social, ethical, aesthetic and option values, India as a mega- diversity nation. Western Ghats as a biodiversity region. Hot-spots of biodiversity, Threats to biodiversity habitat loss, poaching of wildlife, man- wildlife, Conflicts, Endangered and endemic species of India. Conservation of biodiversity: In-situ and Ex-situ conservation Ramsar sites; Biosphere reserves; Protected Areas; Ecologically Sensitive Areas; Coastal Regulation Zone.	07
	Nature Visits / Field Work /Field Tour/ Industrial visits / Activities related to Campus environmental management	05

Text Books	
1.	Agarwal, K. C., (2001), Environmental Biology, Nidi Publ. Ltd., Bikaner.

2.	Bharucha Erach, The Biodiversity of India, Mapin Publishing Pvt. Ltd., Ahmedabad, 380013, India.
3.	Brunner R. C., (1989), Hazardous Waste Incineration, McGraw Hill Inc, 480p.
Reference Books	
1.	Cunningham, W. P. Cooper, T. H. Gorhani, E. & Hepworth, M.T., (2001), Environmental Encyclopedia, Jaico Publ. House, Mumbai, 1196p
2.	Gleick, H., (1993), Water in crisis, Pacific Institute for Studies in Dev., Environment & Security. Stockholm Env. Institute. Oxford Univ. Press 473p.
3.	Hawkins R. e., Encyclopedia of Indian Natural History, Bombay Natural History Society, Bombay (R)
4.	Heywood, V. H. & Watson, R. T., (1995), Global Biodiversity Assessment, Cambridge Univ. Press.
5.	Jadhav, H. & Bhosale, V. M., (1995), Environmental Protection and Laws, Himalaya Pub. House, Delhi, 284p.
6.	Mckinney, M. L. & Schocl. R. M., (1996), Environmental Science Systems & Solutions, Web enhanced edition.
7.	Odum, E. P., (1971), Fundamentals of Ecology, W. B. Saunders Co. USA, 574p.
8.	Rao M. N. & Datta, A. K., (1987), Waste Water Treatment, Oxford & IBH Publ. Co. Pvt. Ltd.
9.	Sharma B. K., (2001), Environmental Chemistry, Goel Publ. House, Meerut.
10.	Trivedi R. K., Handbook of Environmental Laws, Rules, Guidelines, Compliances and Standards, Vol. I and II, Enviro Media (R).
11.	Trivedi R. K. and P. K. Goel, Introduction to air pollution Techno-Science Publications (TB).
12.	Wagner K. D., (1998), Environmental Management, W. B. Saunders Co. Philadelphia, USA.
Important web links	
1.	https://onlinecourses.swayam2.ac.in/cec19_bt03/preview
2.	http://nitttrc.edu.in/nptel/courses/video/109105203/L41.html

Year, Program, Semester	S.Y. B. Tech (Chemical Engineering), Part II, Semester IV							
Course Code	BSC 221							
Course Category	Basic Science Course							
Course title	**Applied Chemistry-II (Organic) (Theory)**							
Teaching Scheme and Credits	**L**	**T**	**P**	**Total Contact Hours**			**Total Credits**	
	03	-	-	03			03	
Evaluation Scheme	**ISE**	**ESE**	**IOE**	**IPE**	**EOE**	**EPE**	**Total**	
	30	70	-	-	-	-	100	
Pre-requisites (if any)	BSC 111, BSC 121, BSC 211							
Course Rationale	The course aims to develop a strong foundation in chemical concepts essential for understanding various engineering disciplines. Through theoretical instruction and laboratory experiments, students will learn about the properties of matter, chemical reactions, and analytical techniques crucial for engineering applications.							
Course Objectives	The Course Teacher will 1. Elaborate fundamental principles and concepts of organic chemistry and their relevance to engineering applications. 2. Discuss basic concepts of Organic chemistry. 3. Explain the basic mechanisms of organic reactions. 4. Discuss the mechanism of cleansing action. 5. Cite the details about dyes and dye intermediates. 6. Explain the processes for producing petrochemicals.							
Course Outcomes	Upon completion of this course, student should be able to 1. Demonstrate a comprehensive understanding of the principles of organic chemistry and their applications in engineering. 2. Recall to basic concepts of Organic Chemistry. 3. Use those mechanisms in the preparation of organic compounds. 4. Describe and classify the mechanism of cleansing action. 5. Classify the different dyes with their applications. 6. Perceive processes for producing petrochemicals.							

Course Outcome and Program Outcome Mapping

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO12
CO1	3	-	-	-	-	-	-	-	-	-	-	-
CO2	2	-	-	-	-	-	-	-	-	-	-	-
CO3	-	3	3	-	-	-	-	-	-	-	-	-
CO4	-	-	-	-	-	2	-	-	-	-	-	-
CO5	-	-	-	-	-	2	-	-	-	-	-	-
CO6	-	-	-	-	-	-	3	-	-	-	-	-

Level of Mapping as: Low 1, Moderate 2, High 3

Unit No.	Course Content	Hours
I	**Concept of Organic Chemistry:** Introduction, Classification of Hydrocarbons, Functional group classification of organic compound, IUPAC system of nomenclature, Isomerism, Types of isomerism: structural, stereoisomerism, Differentiation between organic and inorganic chemistry, Covalent bonding and its significance in organic compounds.	**06**
II	**Unit Processes:** Nitration: Nitrating agents, mechanism of aromatic nitration and industrial nitration of benzene to nitrobenzene by continuous processes. Oxidation: Oxidizing agents, mechanism of oxidation, manufacture of acetic acid by oxidation of acetaldehyde. Halogenations.	**07**
III	**Organic Reactions**: Types of reactions [addition, elimination and substitution reactions] Mechanism in brief and industrial applications of Friedel crafts reactions, Mannich reaction, Gattermann Koch reaction, Claisen rearrangement, Benzidine rearrangement, Cannizzaro reaction, Diels Alder reaction, aldol condensation, Coupling reaction – Mechanism of coupling.	**08**
IV	**Carbohydrates, Soaps & Detergent:** Introduction: Carbohydrates and its classification with suitable Examples, Explain soaps and Detergent, Classification of soaps and detergent with suitable example of each class, Mechanism of cleansing action.	**06**
V	**Chemistry of Dyes & Its Classification:** Definition, Difference between Dye & Colour, Chromogens, Chromophore & Auxochrome, Classification of Dyes base on Structure, Classification of Dyes based on method of application.	**06**
VI	**Chemistry of Petroleum:** Origin of crude, composition, refining of crude, cracking– catalytic cracking- batch process and continuous process, major petrochemicals like ethylene, propylene butadiene, benzene toluene.	**06**
Text Books		
1.	T. L. Brown, H. E. LeMay Jr., B. E. Bursten, C. J. Murphy, P. M. Woodward, M. W. Stoltzfus, 2019, Chemistry: The Central Science, ISBN-978-0134988544, Pearson Publisher.	
2.	D. W. Oxtoby, H. P. Gillis, L. J. Butler., (2017), Principles of Modern Chemistry, ISBN: 978-1305079113, Cengage Learning Publisher.	
3.	R. T. Morrison and R.N. Boyd, (2018), Organic Chemistry, VI Edition Prentice Hall Inc., USA.	
4.	K. S. Tiwari, N. K. Vishnoi and S. N. Malhotra, (1998), A text book of Organic Chemistry, Second Edition, Vikas Publishing House Pvt. Ltd., New Delhi	
5.	J. Clayden, N. Greeves &, S. Warren, (2012), Organic Chemistry, ISBN: 978-0199270293, Oxford University Press.	
6.	K. P. C. Vollhardt, & N. E. Schore, (2018), Organic Chemistry: Structure and Function, ISBN: 978-1429204941, W. H. Freeman.	
Reference Books		
1.	M. B. Smith & J. March, (2012), March's Advanced Organic Chemistry: Reactions,	

	Mechanisms, and Structure, ISBN: 978-1118147290, Wiley.
2.	D. R. Klein, (2016), Organic Chemistry as a Second Language: First Semester Topics. ISBN: 978-1119110668, Wiley.
3.	D. C. Harris, (2015), Quantitative Chemical Analysis, ISBN: 978-1319154141, W. H. Freeman Publishing
Useful web links	
1.	https://www.khanacademy.org/science/organic-chemistry
2.	http://www.chemguide.co.uk/organicprops/menu.html
3.	https://nptel.ac.in/courses/104/104/104104053/
4.	https://nptel.ac.in/courses/104/104/104104054/

<table>
<tr><td>Year, Program, Semester</td><td colspan="7">S.Y. B.Tech (Chemical Engineering) , Part II, Semester IV</td></tr>
<tr><td>Course Code</td><td colspan="7">BSC 221</td></tr>
<tr><td>Course Category</td><td colspan="7">Basic Science Course</td></tr>
<tr><td>Course title</td><td colspan="7">Applied Chemistry-II (Organic) (Practical)</td></tr>
<tr><td rowspan="2">Teaching Scheme and Credits</td><td>L</td><td>T</td><td>P</td><td colspan="2">Total Contact Hours</td><td colspan="2">Credits</td></tr>
<tr><td>-</td><td>-</td><td>02</td><td colspan="2">02</td><td colspan="2">01</td></tr>
<tr><td rowspan="2">Evaluation Scheme</td><td colspan="2">ISE</td><td>ESE</td><td>IOE</td><td>IPE</td><td>EOE</td><td>EPE</td><td>Total</td></tr>
<tr><td colspan="2">-</td><td>-</td><td>50</td><td>-</td><td>-</td><td>-</td><td>50</td></tr>
<tr><td>Pre-requisites (if any)</td><td colspan="7">BSC 111, BSC 121, BSC 211</td></tr>
<tr><td>Course Rationale</td><td colspan="7">This course is designed to provide students with organic chemistry skills relevant to chemical engineering. It covers a range of organic chemistry techniques and reactions, providing students with hands-on experience in synthesis, purification, and analysis of organic compounds, as well as developing critical thinking and problem-solving skills in the laboratory setting.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">The course teacher will ensure
1. Develop proficiency in fundamental organic chemistry laboratory techniques and procedures.
2. Impart theoretical knowledge of organic chemistry concepts to practical laboratory experiments.
3. Guidance about skills in the synthesis, purification, and characterization of organic compounds.
4. Enhance critical thinking and problem-solving abilities through experimental design and analysis.
5. Cultivate an appreciation for the role of experimentation in advancing scientific knowledge and solving real-world problems.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">Upon completion of this course, student should be able to
1. Demonstrate proficiency in performing laboratory experiments in organic, and chemistry.
2. Apply knowledge of reaction mechanisms and principles to successfully execute organic synthesis experiments.
3. Analyze experimental data, interpret results, and draw conclusions, fostering critical thinking and problem-solving skills.
4. Formulate thought process for organic compounds analysis.
5. Tackle on to safety protocols and ethical standards in a laboratory environment.</td></tr>
</table>

Course Outcome and Program Outcome Mapping

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO12
CO1	-	3	3	-	3	-	-	1	-	-	-	-
CO2	-	3	3	-	1	-	-	1	-	-	-	-
CO3	-	3	3	-	1	-	-	1	-	-	-	-
CO4	-	3	3	-	1	-	-	1	-	-	-	-
CO5	-	1	1	-	1	-	-	3	-	-	-	-

Level of Mapping as: Low 1, Moderate 2, High 3

General Instructions: Any 08 experiments to be performed from the list, any 02 experiments to be studied as demonstration.

Experiment No.	Experiment Title/Objective	Hours
1.	Determination of saponification value of the given oil.	**02**
2.	Preparation of salicylic acid from aspirin.	**02**
3.	Isolation of ricinoleic acid from castor oil.	**02**
4.	Preparation of naphthyl benzoate.	**02**
5.	Preparation of acetanilide from aniline and acetyl chloride.	**02**
6.	Analysis of simple organic compounds	**02**
7.	Preparation of soap from a given oil sample	**02**
8.	Estimation of Aniline in the whole of the given solution.	**02**
9.	Estimation of Glucose in the whole of the given solution	**02**
10.	Determination of amount and percentage of aspirin from given sample of tablet	**02**
11.	Estimation of the amount of phenol present in the whole of the given solution	**02**
12.	Preparation of Methylene Blue	**02**
13.	Preparation of Methyl Orange.	**02**
14.	Preparation of Phenolphthalein.	**02**
15.	Hydrolysis of an acetate ester using acid catalysis.	**02**

Text Books/ Reference Books

1.	J. F. Hall, (2006), Experimental Chemistry, ISBN: 978-0495014950, Cengage Learning.
2.	J. R. Dean, A. M. Jones, D. Holmes, R. Reed, J. Weyers, (2009), Practical Skills in Chemistry, ISBN: 978-0273731184, Pearson.

3.	J. R. Mohrig, D. Alberg, G. Hofmeister, P. F. Schatz, C. N. Hammond, (2013), Laboratory Techniques in Organic Chemistry, ISBN: 978-1464134227, W. H. Freeman.
4.	J. C. Gilbert, S. F. Martin, (2014), Experimental Organic Chemistry: A Miniscale & Microscale Approach, ISBN: 978-1305080461, Cengage Learning
5.	D. C. Harris, (2015), Quantitative Chemical Analysis, ISBN: 978-1319154141, W. H. Freeman.
6.	L. M. Harwood, C. J. Moody, (2001), Experimental Organic Chemistry: Standard and Microscale, ISBN: 978-0632056571, Blackwell Science.
Useful Web links	
1.	https://www.chem.wisc.edu/areas/reich/chem545/
2.	http://www.chem.ucalgary.ca/courses/351/Carey/Ch13-14/ch13-14.htm
3.	http://www.chemguide.co.uk/organicprops/practicalmenu.html
4.	https://www.columbia.edu/~lsb25/Books.html

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<tr><td>Course Code</td><td colspan="7">PCC 221</td></tr>
<tr><td>Course Category</td><td colspan="7">Professional Core Course</td></tr>
<tr><td>Course title</td><td colspan="7">Heat Transfer Operations (Theory)</td></tr>
<tr><td rowspan="2">Teaching Scheme and Credits</td><td>L</td><td>T</td><td>P</td><td colspan="2">Total Contact Hours</td><td colspan="2">Total Credits</td></tr>
<tr><td>03</td><td>-</td><td>-</td><td colspan="2">03</td><td colspan="2">03</td></tr>
<tr><td rowspan="2">Evaluation Scheme</td><td>ISE</td><td>ESE</td><td>IOE</td><td>IPE</td><td>EOE</td><td>EPE</td><td>Total</td></tr>
<tr><td>30</td><td>70</td><td>-</td><td>-</td><td>-</td><td>-</td><td>100</td></tr>
<tr><td>Pre-requisites (if any)</td><td colspan="7">BSC 112, BSC 122, BSC 212, PCC 211 and PCC 212</td></tr>
<tr><td>Course Rationale</td><td colspan="7">The main purpose to teach this subject is to study the basics of heat transfer. This subject provides knowledge regarding to the basic modes and aspects of heat transfer process as well as it also provides an idea about various equipment used for heat transfer.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">The Course Teacher will
1. Explain three modes of heat transfer with further detailing of conduction heat transfer.
2. State and distinguish between natural and forced convection with emphasis on various equations governing the same.
3. Detail radiation mode of heat transfer with elaboration of laws pertaining to the same.
4. Discuss heat transfer with change of phase and explain their industrial relevance.
5. Distinguish between different types of evaporators and describe the procedure to select and assess the evaporators.
6. Explain the designing and analysing heat transfer equipment.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">Upon completion of this course, student should be able to
1. Explain three modes of heat transfer with further detailing of conduction heat transfer
2. Memorize the difference between natural and forced examples with suitable examples.
3. Identify examples of heat transfer and apply governing laws to solve the related problems.
4. Distinguish between heat transfer with and without change and perceive condensation and boiling operation w. r. t. heat transfer ideology.
5. Design and analyze heat transfer operations and equipment.
6. Compare performances and select type of heat transfer equipment.</td></tr>
</table>

Course Outcome and Program Outcome Mapping

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	-	-	2	-	-	-	-	-	-	-	-
CO 2	2	-	-	-	1	-	-	-	-	-	-	-
CO 3	3	-	-	2	-	-	-	-	-	-	-	-
CO 4	3	-	-	-	2	-	-	-	-	-	-	-
CO 5	3	3	-	-	-	-	-	-	-	2	-	-
CO 6	2	2	-	-	-	-	-	-	-	-	-	-

Level of Mapping as: Low 1, Moderate 2, High 3

Unit No.	Course Content	Hours
I	**Introduction and Conduction Heat Transfer:** Introduction to three modes of heat transfer: Conduction convection & radiation. General laws of heat transfer. Conduction: Fourier's law, Thermal Conductivity- its variation with temperature and Pressure and its relationship with electrical conductivity. Heat transfer through composite walls and cylinders. Unsteady state heat transfer through some important shapes. Different types of insulating materials, general properties & application of insulators.	**08**
II	**Natural and Forced Convection:** Natural convection from vertical plates and horizontal cylinders. Forced convection: In laminar flow-Heat transfer in plate and tubes. In turbulent flow-Empirical equations for individual coefficients: inside tubes, outside tubes, outside bundle of tubes, flow past spheres. Significance of Prandtl number, Nusselt number, Grashoff number, Graetz number and Peclet number etc. Correction for tube length. Corrections for heating and cooling the fluid. Various analogies between heat & momentum transfer.	**09**
III	**Radiation:** Radiation laws like Stefan Boltzmann's law, Kirchhoff's law, Wien's law, Plank's law etc. Black body, Grey body. Transmissivity, Absorptivity, Reflectivity, Emissivity of black bodies and gray bodies. Application of thermal radiation: Radiation Transfer between surfaces. Radiation through semi-transparent materials.	**06**
IV	**Heat Transfer with Phase Change:** Boiling of liquids, Pool boiling curve, different types of pool boiling, Condensation of vapor, film wise and drop wise condensation, weighted LMTD & Overall Heat transfer Coefficient for de superheating & sub cooling.	**04**
V	**Evaporation:** Performance of tubular evaporator. Individual & overall Coefficients, Capacity & economy of evaporators. Boiling point elevation, Duhring's rule, Effect of liquid head & friction on pressure drop, Types of evaporators, multiple effect evaporators. Vapor recompression, Thermal recompression & mechanical recompression.	**05**
VI	**Heat Exchange Equipment:** Double pipe heat exchangers. Individual and overall heat transfer coefficient, LMTD, Variable overall Heat transfer coefficient, fouling	**07**

	factors, Shell & tube heat exchangers, LMTD correction factors, extended surface heat exchangers, Fin efficiency and fin effectiveness.	
Text Books		
1.	D. Q. Kern, (1950), 'Process Heat Transfer', 2nd Edition, McGraw Hill.	
2.	McCabe W L, Smith J C, Harriot P, (1993), 'Unit Operations of Chemical Engineering',7th Edition, McGraw Hill.	
3.	J. P. Holman, (1963), 'Heat Transfer', 10th Edition, McGraw Hill.	
Reference Books		
1.	Richardson J.E. and Coulson, (1977), 'Chemical Engineering', Volume1, 5th Edition, Butterworth-Heinemann.	
2.	Don W. Green, Robert H. Perry, (1934), 'Perry's Chemical Engineer's Handbook', 8th Edition, McGraw Hill.	
3.	John H. Lienhard, (1981) 'A Heat Transfer Textbook', 5th Edition, Phlogiston Press, Cambridge, Massachusetts.	
4.	Yunus A. Cengel, (1998), 'Heat Transfer: A Practical Approach', McGraw Hill.	

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<tr><td>Pre-requisites (if any)</td><td colspan="7">BSC 112, BSC 122, BSC 212, PCC 211 and PCC 212</td></tr>
<tr><td>Course Rationale</td><td colspan="7">This course provides fundamental and industrial knowledge about modes of heat transfer, like conduction, convection and radiation, and their application. The laboratory work consists of various equipment used to verify basis laws and study modes of heat transfer, also it provides knowledge regarding various heat transfer process as well as it also provides an idea about various equipment used for heat transfer.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">The Course Teacher will
1. Explain fundamental modes of heat transfer operations through experimental set ups.
2. Organize the hands-on training on important heat transfer devices and motivate them for team work.
3. Expose and elaborate laboratory practices like a miniature process plant environment using steam and the other process utilities.
4. Develop skills for safe handling of major heat transfer equipment/devices.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">Upon completion of this course, student should be able to
1. Verify fundamentals laws of Heat transfer through practical work.
2. Demonstrate various practical experiments related heat transfer operations.
3. Apply of heat transfer design principles and operate heat transfer devices.
4. Build foundation for process intensification and adapt to handle heat transfer operations.</td></tr>
</table>

Course Outcome and Program Outcome Mapping

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO1	2	-		2	-	-	-	-	-	-	-	-
CO2	-	-	-	-	-	-	-	3	-	2	-	-

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

Level of Mapping as: Low 1, Moderate 2, High 3

General Instructions: Any 8 experiments to be performed from the list, any 2 experiments to be studied as demonstration.

Experiment No.	Experiment Title/Objective	Hours
1.	To understand conduction heat transfer.	**02**
2.	To understand conduction heat transfer through composite system.	**02**
3.	To study heat flow through a sphere and to estimate thermal conducting of powdered insulating material using the set up.	**02**
4.	To estimate thermal conductivity of liquid.	**02**
5.	To analyse problems involving steady state heat conduction in simple geometries with lagged material.	**02**
6.	To estimate the film heat transfer coefficient between the medium in which body is heated.	**02**
7.	To understand heat transfer during agitation and mixing.	**02**
8.	To understand fundamentals of convective heat transfer process and to evaluate heat transfer coefficients for natural convection.	**02**
9.	To understand fundamentals of convective heat transfer process and to evaluate heat transfer coefficients for forced convection	**02**
10.	To understand radiation heat transfer through verification of the basic law of radiation.	**02**
11.	To understand radiation heat transfer and to evaluate emissivity of a material.	**02**
12.	Analyse heat exchanger performance of different types of heat exchangers.	**02**
13.	To study the basic operation of evaporation in the context of heat transfer.	**02**
Reference Books /Text Books/Manual		
1.	D. Q. Kern, (1950), 'Process Heat Transfer', 2nd Edition, McGraw Hill.	
2.	Institute's Laboratory Course Manual and equipment wise Standard Operating Procedure to follow.	

<table>
<tr><td>Year, Program, Semester</td><td colspan="7">S.Y. B.Tech (Chemical Engineering) , Part II, Semester IV</td></tr>
<tr><td>Course Code</td><td colspan="7">PCC 222</td></tr>
<tr><td>Course Category</td><td colspan="7">Professional Core Course</td></tr>
<tr><td>Course title</td><td colspan="7">Mechanical Operations (Theory)</td></tr>
<tr><td rowspan="2">Teaching Scheme and Credits</td><td>L</td><td>T</td><td>P</td><td colspan="2">Total Contact Hours</td><td colspan="2">Total Credits</td></tr>
<tr><td>03</td><td>-</td><td>-</td><td colspan="2">03</td><td colspan="2">03</td></tr>
<tr><td rowspan="2">Evaluation Scheme</td><td colspan="2">ISE</td><td>ESE</td><td>IOE</td><td>IPE</td><td>EOE</td><td>EPE</td><td>Total</td></tr>
<tr><td colspan="2">30</td><td>70</td><td>-</td><td>-</td><td>-</td><td>-</td><td>100</td></tr>
<tr><td>Pre-requisites(if any)</td><td colspan="7">BSC121, BSC211, BSC221, PCC 211</td></tr>
<tr><td>Course Rationale</td><td colspan="7">This course covers all those unit operations that involve physically changing a material. This generally refers to change in size reduction or enlargement or shape, it is not limited to that. The contents also include separation of material on the basis of physical/mechanical properties like density, size, wet ability, etc. Mechanical operations may either be individual operations or may be a part of an entire process. Chemical engineers should have knowledge of mechanical operations as very often we do not have the raw material feed in a desirable form so is the course incorporated in this curriculum.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">The Course Teacher will
1. Discuss importance of properties and handling of particulate solids.
2. Explain concept, terminologies and laws pertaining to size reduction.
3. Describe the fluid-solid system.
4. Illustrate the sedimentation process; and thickeners.
5. Classify filtration processes, techniques and show how to make related calculations.
6. Discuss the concept of mixing and agitation operation.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">Upon completion of this course, student should be able to
1. Relate the importance of properties and handling of particulate solids.
2. Solve size reduction related problems using crushing laws and screening of the particulate solids.
3. Express the flow of fluid past immersed bodies and motion of particles through fluids for fluid-solid system.
4. Perceive the processes of sedimentation and settling of solid particle in a liquid.
5. Recognize importance of filtration process, perceive different techniques & make related calculations.
6. Apply knowledge to practice various mixing processes.</td></tr>
</table>

Course Outcome and Program Outcome Mapping

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO1	3	1	1	-	-	-	-	-	-	-	-	1
CO2	3	3	2	2	1	-	-	-	-	-	-	1
CO3	3	2	2	1	-	-	-	-	-	-	-	1
CO4	3	2	1	1	-	-	1	-	-	-	-	1
CO5	3	2	-	2	-	-	1	-	-	-	-	1
CO6	3	2	1	-	-	-	1	-	-	-	-	1

Level of Mapping as: Low 1, Moderate 2, High 3

Unit No.	Course Content	Hours
I	**Properties and Handling of Particulate Solids:** Particle characterization, Particle size measuring technologies, Particle size distribution, Mean particle size, mixed particle sizes and shape. Properties of solid masses, Storage of solids (Bulk and Bin), Flow through Hoppers, Angle of repose and angle of friction, Introduction to conveying of solids	**07**
II	**Size Reduction and Screening:** Mechanism of size reduction, Energy for size reduction, crushing laws, Methods of operating crushers, Classification of size reduction equipment, Types of crushing equipment, Factors affecting comminution, Heat control methods in size reduction. Standard test screens, Standards of screen, Screen effectiveness, Comparison of ideal and actual screens, Industrial screening equipment.	**07**
III	**Fluid-Solid System:** Flow of Fluid Past Immersed Bodies: Drag, drag coefficient, Pressure drop in a bed of solids– Kozeny – Carman equation, Burke- Plummer equation, Ergun equation, Fluidization - conditions for fluidization, minimum fluidization velocity, types of fluidizations, applications of fluidization, slurry transport, pneumatic conveying. Motion of Particles Through Fluids: Mechanics of particle motion, equation for one dimensional motion of particles through a fluid in gravitational and centrifugal field, terminal velocity, drag coefficient, motion of spherical particles in various regimes, criterion for settling regime, hindered settling, modification of equation for hindered settling, centrifugal separators, cyclones and hydro-cyclones.	**07**
IV	**Sedimentation:** Batch settling test and its applications, Coe and Clevenger theory, Kynch theory of sedimentation, thickener design, types of thickeners, and components of thickeners.	**05**
V	**Filtration:** Classification of filtration, Types of filtrations, Pressure drop through filter cake, Filter medium resistance, cake resistance, Washing of cake, Filter media and selection, Compressible filter cakes, Preliminary treatment of slurries before filtration, Filtration equipment, Filter selection, Filter press, Vacuum filters, Centrifugal filtration and Filtration calculations.	**07**
VI	**Agitation and Mixing:** Agitation equipment, Types of impellers–Propellers, Paddles and Turbines, Flow patterns in agitated vessels, Prevention of swirling, Standard turbine design, Power correlation and Power calculation, Mixing of solids, Various types of mixers and blenders.	**06**

Text Books	
1.	McCabe, W.L., Smith, J.C., & Harriott, P. (1993). Unit Operations of Chemical Engineering (5th ed.). McGraw Hill International, Chemical and Petroleum Engineering Series.
2.	Narayanan, C.M., & Bhattacharyya, B.C., (2011), Mechanical Operations for Chemical Engineers, Computer Aided Analysis (3rd ed.), Khanna Publishers.
3.	Coulson, J.M., Richardson, J.F., Backhurst, J.R. & Harker, J.H., (2002), Coulson & Richardson's Chemical Engineering, Particle Technology and Separation Process (5th ed.), Butterworth-Heinemann, Oxford.
4.	Hiremath R.S., & Kulkarni, A.P. (2013). Unit operations of chemical engineering (mechanical operations) (18th ed.). Everest publishing house.
Reference Books	
1.	Foust, A.G., (1979), Principles of Unit Operations (2nd ed.) John, Wiley & Sons, New York.
2.	Sekhar, G.C., (2005), Unit Operations in Chemical Engineering (7th ed.), Pearson education (Singapore) ltd.
3.	Perry, R.H. & Chilton C.H., (1997), Chemical Engineers Hand Book (7th ed.), McGraw hill.
4.	Gavhane, K.A., (2016), Unit Operations-I, Fluid Flow & Mechanical Operation. Nirali Prakashan.
5.	Rhodes, M., (2008), Introduction to Particle Technology (2nd ed.). John Wiley & Sons.
6.	Lee, S., & Henthorn. K. H., (2017), Particle Technology and Applications, CRC Press.

<table>
<tr><td>Year, Program, Semester</td><td colspan="7">S.Y. B.Tech (Chemical Engineering) , Part II , Semester IV</td></tr>
<tr><td>Course Code</td><td colspan="7">PCC 222</td></tr>
<tr><td>Course Category</td><td colspan="7">Professional Core Course</td></tr>
<tr><td>Course title</td><td colspan="7">Mechanical Operations (Practical)</td></tr>
<tr><td rowspan="2">Teaching Scheme and Credits</td><td>L</td><td>T</td><td>P</td><td colspan="2">Total Contact Hours</td><td colspan="2">Credits</td></tr>
<tr><td>-</td><td>-</td><td>02</td><td colspan="2">02</td><td colspan="2">01</td></tr>
<tr><td rowspan="2">Evaluation Scheme</td><td colspan="2">ISE</td><td>ESE</td><td>IOE</td><td>IPE</td><td>EOE</td><td>EPE</td><td>Total</td></tr>
<tr><td colspan="2">-</td><td>-</td><td>-</td><td>50</td><td>-</td><td>50</td><td>100</td></tr>
<tr><td>Pre-requisites(if any)</td><td colspan="7">BSC121, PCC 211</td></tr>
<tr><td>Course Rationale</td><td colspan="7">The course covers the hands-on experience of working by conducting experiments on most of the basic unit operations under the category of mechanical operations such as ball mill, jaw crusher, cyclone separator, filtration equipment, sieve analysis, hydraulic classifier, sedimentation etc.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">The Course Teacher will
1. Demonstrate operations of types of crushers for size reduction of feed.
2. Explain and demonstrate the process of sedimentation and mixing of fluid.
3. Demonstrate working of different filtration techniques & various gas cleaning equipment.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">The students will be able to
1. Analyse the sizes of particulate material after having size reduced.
2. Select and classify the appropriate operations for separation of solid and fluids.
3. Handle and demonstrate the filtration equipment with enhanced technical skills.</td></tr>
</table>

Course Outcome and Program Outcome Mapping

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO12
CO 1	3	2	2	-	-	1	2	-	2	-	-	1
CO 2	3	2	1	-	-	-	2	-	2	-	-	1
CO 3	3	2	1	-	-	-	2	-	2	-	-	1

Level of Mapping as: Low 1, Moderate 2, High 3

General Instructions: Any 8 experiments to be performed from the list, any 2 experiments to be studied as demonstration.		
Experiment No.	**Experiment Title/Objective**	**Hours**
1.	To study the cumulative and differential analysis of a given sample.	**02**
2.	To determine the effectiveness of a given standard screen.	**02**
3.	To determine overall efficiency of cyclone separator.	**02**
4.	To determine the size reduction and sieve analysis of jaw crusher.	**02**
5.	To determine the size reduction and sieve analysis of roll crusher.	**02**
6.	To determine the size reduction and sieve analysis of rod mill.	**02**
7.	To determine the reduction ratio and critical speed of ball mill.	**02**
8.	To determine the size reduction and sieve analysis of hammer mill.	**02**
9.	To study the batch sedimentation process and determine the area of continuous thickener with the help of data on the batch sedimentation.	**02**
10.	To study the working of sigma mixer and determine its mixing index.	**02**
11.	To study the working of plate and frame filter press.	**02**
12.	To study the working of vacuum leaf filter.	**02**
13.	To study of fluid mixing.	**02**
Text Books		
1.	McCabe, W.L., Smith, J.C., & Harriott, P., (1993), Unit Operations of Chemical Engineering (5^{th} ed.), McGraw Hill International, Chemical and Petroleum Engineering Series.	
2.	Narayanan, C.M., & Bhattacharyya, B.C., (2011), Mechanical Operations for Chemical Engineers, Computer Aided Analysis (3^{rd} ed.), Khanna Publishers.	
3.	Coulson, J.M., Richardson, J.F., Backhurst, J.R. & Harker, J.H., (2002,). Coulson & Richardson's Chemical Engineering, Particle Technology and Separation Process (5^{th} ed.), Butterworth-Heinemann, Oxford.	
4.	Hiremath R.S., & Kulkarni, A.P., (2013), Unit operations of chemical engineering (mechanical operations) (18^{th} ed.), Everest publishing house.	
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1.	Foust, A.G., (1979), Principles of Unit Operations (2nd ed.) John, Wiley & Sons, New York.	
2.	Sekhar, G.C., (2005), Unit Operations in Chemical Engineering (7th ed.). Pearson education (Singapore) ltd.	
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4.	Gavhane, K.A. (2016), Unit Operations-I, Fluid Flow & Mechanical Operation. Nirali Prakashan.
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6.	Lee, S., & Henthorn, K. H., (2017), Particle Technology and Applications. CRC Press.

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<tr><td>Year, Program, Semester</td><td colspan="7">S.Y. B.Tech (Chemical Engineering) , Part II ,Semester IV</td></tr>
<tr><td>Course Code</td><td colspan="7">PCC 223</td></tr>
<tr><td>Course Category</td><td colspan="7">Professional Core Course</td></tr>
<tr><td>Course title</td><td colspan="7">Inorganic Chemical Technologies</td></tr>
<tr><td rowspan="2">Teaching Scheme and Credits</td><td>L</td><td>T</td><td>P</td><td colspan="2">Total Contact Hours</td><td colspan="2">Total Credits</td></tr>
<tr><td>03</td><td>-</td><td>-</td><td colspan="2">03</td><td colspan="2">03</td></tr>
<tr><td rowspan="2">Evaluation Scheme</td><td colspan="2">ISE</td><td>ESE</td><td>IOE</td><td>IPE</td><td>EOE</td><td>EPE</td><td>Total</td></tr>
<tr><td colspan="2">30</td><td>70</td><td>-</td><td>-</td><td>-</td><td>-</td><td>100</td></tr>
<tr><td>Pre-requisites (if any)</td><td colspan="7">BSC211, BSC212, PCC212, ESC211</td></tr>
<tr><td>Course Rationale</td><td colspan="7">Chemical Industries are the prime factors to convert the raw materials into desired products that we use in daily life. This sector has brought a tremendous change in the way the things operate. It is very important for us to understand the importance of the chemical industry which has touched all our facets of life like agriculture, environment, food, hygiene, catalysis, construction etc. It has also significantly used in re-cycling industries to curb the usage of virgin products. The proposed course will cover all these aspects in relation to the developments at the international level.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">The Course Teacher will
1. Impart knowledge of sources and processes for manufacture of various fuels and fuel gases manufactured or used in industry.
2. Explain various processes for manufacture of chlor-alkali products and potassium and its compounds.
3. Discuss various manufacturing processes for Sulphur compounds.
4. Elaborate different methods used for manufacture of phosphorous compounds.
5. Explain various manufacturing processes and applications for nitrogen-based compounds.
6. Discuss various manufacturing processes for cement and ceramic based compounds.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">Upon completion of this course, student should be able to
1. Identify and select various fuels and fuel gases for different applications.
2. Understand manufacturing of different chlor-alkali and potassium compounds and their uses.
3. Identify correct process for production of Sulphur for industrial application purpose.
4. Differentiate between different methods for phosphorous production.</td></tr>
</table>

	5. Outline manufacturing methods for production and applications of nitrogen compounds. 6. Understand manufacturing of different cement, glass and ceramic based compounds and their uses.

Course Outcome and Program Outcome Mapping

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO1	-	3	3	-	3	3	3	-	3	-	-	-
CO2	-	3	3	3	-	3	3	-	3	-	-	-
CO3	-	3	3	3	-	3	3	-	3	-	-	-
CO4	-	3	3	3	-	3	3	-	3	-	-	-
CO5	-	3	3	3	-	3	3	-	3	-	-	-
CO6	-	3	3	-	3	3	3	-	3	-	-	3

Level of Mapping as: Low 1, Moderate 2, High

Unit No.	Course Content	Hours
I	**Fuel Gases and Industrial Gases:** Introduction to Chemical Manufacturing and Processing sector. Study of the role of Chemical Engineers and Technologists in the development of the nation. Study of the manufacture: water gas, producer gas, natural gas, LPG, hydrogen and acetylene.	**06**
II	**Chlor-Alkali and Potassium Industries:** Manufacture of Soda ash, caustic soda, chlorine, sodium sulphate and by-products, bleaching powder, sodium bicarbonate, Bayer's process Manufacture of potassium, derivatives of potassium, Manufacture of potassium chloride, potassium nitrate.	**07**
III	**Sulfur and Sulphuric Acid Industries:** Mining of Sulphur and manufacture of sulphuric acid. Manufacture of hydrochloric acid, Manufacture of sulphuric acid aluminium sulphate and alums.	**07**
IV	**Phosphorus Industries:** Study of elemental phosphorous, manufacture of phosphoric acid, Manufacture of ammonium phosphate, Super phosphate and Triple Super phosphate manufacture, baking powder.	**06**
V	**Nitrogen Industries:** Manufacture of synthetic ammonia, nitric acid, urea, ammonium nitrate, Ammonium Sulphate.	**06**
VI	**Cement, Lime, Glass and Ceramic Industries:** Cement manufacturing process: quarrying, crushing, grinding, and blending, Properties of cement: strength, setting time, durability, Lime Production and Applications, Glass Industries, Ceramic Chemistry, Whitewares and Structural Clay Products, Refractories, Specialized Ceramic Products and Vitreous Enamel.	**07**

Text Books	
1.	G. Rao and M. Sittig, (2000), Dryden's Outlines of Chemical Technology, 3rd Edition, East–West Press Pvt Ltd., New Delhi
2.	G. T. Austin, (1985), Shreve's Chemical Process Industries, 5th edition. , McGraw Hill Book Company.
3.	P. H. Groggins, (1984), Unit Processes in Organic Synthesis, 5th Edition, McGraw Hill.
4.	S. D. Shukla and G. N. Pandey, (1977), Text book of Chemical Technology, Vikas Publishing House Private Ltd.
5.	J. K. Moulijn, M. Makkee and D. A. V. Diepen, (2001), Chemical Process Technology, Wiley.
Reference Books	
1.	D. Venkteshwaralu, (1977), Chemical Technology, I & III manuals of Chemical Technology, Chemical Engineering. Ed. Dev. III Madras.
2.	R. H. Perry, D. W. Green, (2007), Perry's chemical Engineer's Handbook, McGraw Hill, New York.
3.	R. E. Kirk and D. F. Othmer, (1991), Encyclopaedia of Chemical Technology, 4th Edition, Interscience, New York.
Useful web links	
1.	https://nptel.ac.in/courses/104103069
2.	https://onlinecourses.nptel.ac.in/noc24_ch33/preview
3.	https://www.journals.elsevier.com/inorganic-chemistry-communications
4.	https://www.acs.org/

<table>
<tr><td>Year, Program, Semester</td><td colspan="8">S.Y. B.Tech (Chemical Engineering) , Part II ,Semester IV</td></tr>
<tr><td>Course Code</td><td colspan="8">PCC 224</td></tr>
<tr><td>Course Category</td><td colspan="8">Professional Core Course</td></tr>
<tr><td>Course title</td><td colspan="8">Chemical Process Calculations</td></tr>
<tr><td rowspan="2">Teaching Scheme and Credits</td><td>L</td><td>T</td><td>P</td><td colspan="3">Total Contact Hours</td><td colspan="2">Credits</td></tr>
<tr><td>03</td><td>01</td><td>-</td><td colspan="3">04</td><td colspan="2">04</td></tr>
<tr><td rowspan="2">Evaluation Scheme</td><td colspan="2">ISE</td><td>ESE</td><td>IOE</td><td>IPE</td><td>EOE</td><td>EPE</td><td>Total</td></tr>
<tr><td colspan="2">30</td><td>70</td><td>-</td><td>-</td><td>-</td><td>-</td><td>100</td></tr>
<tr><td>Pre-requisites(if any)</td><td colspan="8">BS 11A1, BS11A2, BS12A1 and BS12A2</td></tr>
<tr><td>Course Rationale</td><td colspan="8">The prime objective of this subject is to clear fundamentals of chemical engineering in a simple and forthright manner and to provide the broad background for applying these principles to industrial and theoretical problems.</td></tr>
<tr><td>Course Objectives</td><td colspan="8">The Course teacher will
1. Guide students in mastering fundamental chemical calculations for practical application.
2. Emphasize to students the importance of material and energy balance in chemical industries.
3. Provide instruction to build strong mathematical skills for solving balance problems.
4. Facilitate hands-on data analysis experience for students to solve unit operation problems.
5. Instruct students in applying Chemical Engineering and Mathematics principles to balance problems.
6. Teach students how to write mass balances for process equipment and chemical reactions, including recycling.</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">Upon completion of this course, student should be able to
1. Demonstrate proficiency in applying fundamental chemical calculations to real-world scenarios.
2. Exhibit an understanding of the significance of material and energy balance in chemical processes.
3. Apply various mathematical techniques effectively to solve material and energy balance problems.
4. Analyse and interpret solutions to unit operation problems through data analysis and material balances.
5. Apply principles of Chemical Engineering and Mathematics to analyse and solve material and energy balance problems.
6. Develop the ability to write mass balances for process equipment and chemical reactions, considering recycling processes.</td></tr>
</table>

Course Outcome and Program Outcome Mapping

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO1	3	2	2	2	1	-	-	-	-	-	-	2
CO2	3	2	2	2	1	-	-	-	-	-	-	2
CO3	3	3	3	3	2	-	-	-	-	-	-	2
CO4	3	3	3	3	2	-	-	-	-	-	-	2
CO5	3	3	3	3	2	-	-	-	-	-	-	2
CO6	3	3	3	2	2	-	-	-	-	-	-	2

Level of Mapping as: Low 1, Moderate 2, High 3

Unit No.	Course Content	Hours
I	**Basic Chemical Calculations:** Units and Conversions, Pressure, Temperature, Density, Specific Gravity; Mole Concept, Equivalent Weight, Composition of solids, Liquids and Gases, Mass fraction, Mass percent, Mass Ratios, Mole fraction, Mole percent, Volume fraction and Volume percent, Normality, Morality , Molality.	06
II	**Gaseous Systems:** Gaseous mixtures, Daltons law, Amagat's law, Average molecular weight, Density of gaseous mixture, Estimation of vapour pressure.	06
III	**Material Balances without Chemical Reaction:** Material balances Guidelines for solving material balance problems; Material balance of important industrial operations (Distillation, Absorption and Striping, Extraction and Leaching, Evaporation, Dryer, Mixing, Crystallization etc.); Recycle and Bypass operations.	07
IV	**Material Balances with Chemical Reaction:** Definition of terms involved; Generalized approach for solving problems; Material balance problems involving chemical reaction; Electrochemical reactions; Metallurgical applications; Recycle, bypass and purge calculations.	07
V	**Energy Balance on Non-Reactive and Reactive Processes:** Elements of energy balance calculations; Change in pressure at constant temperature; Change in temperature; Phase change operations; Mixing and solutions. Heat of reaction Measurement and calculation of standard heat of reaction, Hess law; Heat of formation; Heat of combustion; Effect of temperature on heat of reaction; adiabatic reactions.	07
VI	**Fuels and combustion:** Types of fuels, Calorific value of fuels, Problems on combustion of coal, liquid fuels, gaseous fuels, etc., Proximate and ultimate analysis, Combustion calculations, theoretical flame temperature, etc., Air requirement and flue gases.	06

Text Books	
1.	Bhatt, B.I., Vora, S.M. (2004). "Stoichiometry". 4th edition. McGraw Hill Publishing Company Limited.
2.	Himmelblau, D.M., Riggs, J.B. (2006). "Basic Principles & Calculations in Chemical Engineering". 7th edition. PHI Learing Pvt. Ltd.
3.	Narayanan, K.V., Lakshmikutty, B. (2006). "Stoichiometry and Process Calculations". Prentice-Hall of India Pvt. Ltd.
4.	Gavhane, K.A. (2009). "Introduction to Process Calculations Stoichiometry". Twenty-second Edition. Nirali Prakashan.
Reference Books	
1.	Felder, R.M., Rousseau, R.W. (2004), "Elementary Principles of Chemical Processes". 3rd edition. Wiley.
2.	Hougen, O.A., Watson, K.M., Ragatz, R.A. (2004), "Chemical Process Principles Part-I: Material and Energy Balances". 2nd edition. CBS Publishers New Delhi.
3.	Lewis, H.C., Lewis, W.K., Radasch, A.H. (1954). "Industrial Stoichiometry: Chemical Calculations of Manufacturing Processes". 2nd edition. McGraw-Hill.
4.	Venkataramani, V., Anantharaman, N. (2011), "Process Calculations".2nd edition, PHI Learning Pvt.Ltd.
5.	Felder, R.M., Rousseau, R.W. (2000), "Elementary Principles of Chemical Processes". Third Edition. John Wiley and Sons, Inc.
6.	Himmelblau, D.M. (2004), "Basic Principles and Calculations in Chemical Engineering". Sixth Edition. Prentice-Hall of India Pvt. Ltd.

<table>
<tr><td>Year, Program, Semester</td><td colspan="7">S.Y. B. Tech (Chemical Engineering) , Part II ,Semester IV</td></tr>
<tr><td>Course Code</td><td colspan="7">IKS 221</td></tr>
<tr><td>Course Category</td><td colspan="7">Indian Knowledge Systems</td></tr>
<tr><td>Course title</td><td colspan="7">Introduction to Performing Arts</td></tr>
<tr><td rowspan="2">Teaching Scheme and Credits</td><td>L</td><td>T</td><td>P</td><td colspan="2">Total Contact Hours</td><td colspan="2">Total Credits</td></tr>
<tr><td>01</td><td>-</td><td>-</td><td colspan="2">01</td><td colspan="2">01</td></tr>
<tr><td rowspan="3">Evaluation Scheme</td><td colspan="2">ISE</td><td>ESE</td><td>IOE</td><td>IPE</td><td>EOE</td><td>EPE</td><td>Total</td></tr>
<tr><td colspan="2">-</td><td>-</td><td>50</td><td>-</td><td>-</td><td>-</td><td>50</td></tr>
<tr><td colspan="8">IE at the course in charge end: (Preferred to have 4 assignments and conduct of an MCQ Test based on the course work. Passing is mandatory to earn the credit.</td></tr>
<tr><td>Pre-requisites(if any)</td><td colspan="7">No pre-requisite as such is needed however students' involvement and interest in the classroom will make it more lively activity.</td></tr>
<tr><td>Course Rationale</td><td colspan="7">The course seeks to broaden the horizons of engineering students by integrating the rich and diverse realm of performing arts into their curriculum. By exploring various performing arts forms, students will not only develop a deeper understanding of human expression but also enhance their creativity, communication skills, and cultural awareness. This interdisciplinary approach aligns with NEP 2020's vision of holistic education and fosters the development of well-rounded individuals equipped to thrive in a rapidly evolving world.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">The Course Teacher will
1. Introduce fundamental concepts, history, and theoretical frameworks of various performing arts forms.
2. Cultivate appreciation for cultural, social, and aesthetic dimensions of performing arts.
3. Develop critical thinking and analytical skills through performance analysis.
4. Enhance communication and presentation skills through practical exercises.
5. Foster creativity and imagination through exploration of diverse performing arts mediums.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">By the end of the course, students will be able to
1. Identify and analyze key elements and techniques across theater, dance, music, and visual arts.
2. Demonstrate understanding of historical, cultural, and social contexts in performing arts.
3. Critically evaluate performances using appropriate terminology.
4. Apply performance principles to effectively communicate ideas and emotions.
5. Engage in creative expression through original performances.</td></tr>
</table>

Course Outcome and Program Outcome Mapping

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	-	-	-	-	1	3	-	-	3	-	-	-
CO 2	-	-	-	-	-	3	2	-	-	-	-	-
CO 3	-	-	-	-	-	-	2	-	3	3	-	-
CO 4	-	-	-	-	-	2	-	2	3	3	-	-
CO 5	-	-	-	-	-	-	-	-	-	-	2	2

Level of Mapping as: Low 1, Moderate 2, High 3

Unit No.	Course Content	Hours
I	**Foundations of Performing Arts**: • Introduction to Performing Arts: Definition, scope, and significance. • Historical overview: Evolution of performing arts across cultures and civilizations.	02
II	**Theatrical Arts:** • Introduction to theatre: Origins, elements, and dramatic conventions. • Major theatrical movements and styles: Realism, surrealism, absurdism, etc. • Analysis of selected plays and playwrights	03
III	**Dance Forms:** • Introduction to dance: Styles, techniques, and cultural contexts. • Exploration of classical, folk, and contemporary dance forms. • Practical exercises and choreography workshops	03
IV	**Musical Expressions:** • Introduction to music: Basic principles, genres, and traditions. • Appreciation of classical, folk, and popular music styles. • Analysis of musical compositions and performances.	02
V	**Visual Performing Arts:** • Introduction to visual arts in performance: Set design, costume, and makeup. • Role of visual elements in enhancing the theatrical experience. • Case studies and practical demonstrations.	02
VI	**Performance and Presentation:** • Practical application of performing arts principles: Group performances and presentations. • Rehearsal techniques, stage presence, and audience engagement. • Reflection and feedback on individual and group performances	02
Reference Books		

1.	Bharata Muni, Natyashastra, An ancient Indian treatise on performing arts covering various aspects of classical dance, music, and drama, composed between 200 BCE and 200 CE, influencing the theory and practice of Indian performing arts for centuries.
2.	Girish Karnad. (2005). Collected Plays: Volume 1. Oxford University Press.
3.	Mohan Khokar. (2000). Traditions of Indian Classical Dance. Clarion Books.
4.	Sunil Kothari. (2001). Kathak, Indian Classical Dance Art. Abhinav Publications.
5.	Sangeet Natak Akademi. (2005). Indian Music: Tradition and Trends. Sangeet Natak Akademi.
6.	P. Sambamurthy. (2010). South Indian Music, Vol. 1. The Indian Music Publishing House.
7.	Kapila Vatsyayan. (2007). Indian Classical Dance: Tradition in Transition. Publications Division, Ministry of Information and Broadcasting, Government of India.
8.	Vijay Tendulkar. (2010). Collected Plays in Translation. Oxford University Press.
Useful web links	
1.	https://www.youtube.com/watch?v=W7bEzgZrN7s
2.	https://www.youtube.com/watch?v=DQbNpx_CfJY
3.	https://www.youtube.com/watch?v=eGiz50aVYWQ

<table>
<tr><td>Year, Program, Semester</td><td colspan="5">S.Y. B.Tech (Chemical Engineering) , Part II ,Semester IV</td></tr>
<tr><td>Course Code</td><td colspan="5">MAC 221</td></tr>
<tr><td>Course Category</td><td colspan="5">Mandatory Audit Course</td></tr>
<tr><td>Course title</td><td colspan="5">Aptitude Enhancement Course I</td></tr>
<tr><td rowspan="2">Teaching Scheme and Credits</td><td>L</td><td>T</td><td>P</td><td>Total Contact Hours</td><td>Total Credits</td></tr>
<tr><td>01</td><td>-</td><td>-</td><td>01</td><td>00</td></tr>
<tr><td>Evaluation Scheme</td><td colspan="5">IE at the course in charge end. There is a detailed mention under the course assessment method.</td></tr>
<tr><td>Pre-requisites (if any)</td><td colspan="5">NA</td></tr>
<tr><td>Course Rationale</td><td colspan="5">This Aptitude Enhancement Course I aims to nurture holistic development among second-year B. Tech. Engineering students by focusing on enhancing their critical thinking, problem-solving skills, creativity, and emotional intelligence. Aligned with the NEP 2020 and Outcome-Based Education (OBE) philosophy, the course seeks to empower students with essential aptitudes required for success in both academic and professional domains.</td></tr>
<tr><td>Course Objectives</td><td colspan="5">The course teacher will ensure to
1. Equip students with critical thinking skills through analytical exercises and problem-solving tasks.
2. Foster creativity and innovation by engaging students in structured workshops and practical projects.
3. Develop students' emotional intelligence through self-awareness activities and stress management techniques.
4. Enhance collaborative skills and effective communication through group discussions and team-based projects.</td></tr>
<tr><td>Course Outcomes</td><td colspan="5">By the end of the course, the students will be able to
1. Demonstrate proficiency in critical thinking by analysing complex problems and proposing effective solutions.
2. Exhibit creativity through the development of innovative projects and solutions.
3. Display heightened emotional intelligence by managing stress, communicating empathetically, and resolving conflicts constructively.
4. Showcase collaborative skills by actively participating in group activities, contributing to team goals, and communicating ideas effectively.</td></tr>
</table>

Course Outcome and Program Outcome Mapping

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	-	2	-	2	-	-	-	-	-	3	-	-
CO 2	-	2	-	-	2	1	-	-	-	-	-	-
CO 3	-	-	-	-	-	3	2	3	-	-	-	-
CO 4	-	-	-	-	-	-	-	-	3	3	2	1

Level of Mapping as: Low 1, Moderate 2, High 3

Sr. No.	Course Content	Hours
1.	Inter-Personal & Inter-Organizational Communication.	**02**
2.	Creative & Critical Thinking.	**02**
3.	Group Dynamics & Decision-Making Techniques.	**02**
4.	Emotional Intelligence & Stress Management Strategies.	**03**
5.	Assessment.	**04**
6.	Inter-Personal & Inter-Organizational Communication.	**02**

Course Assessment Method

For the internal assessment of the course, total evaluation is of 50 marks. Combination of different evaluation methods can be utilized to ensure comprehensive assessment of the students' performance. The assessment will focus real-world scenarios that require the application of critical thinking, problem-solving, creativity, emotional intelligence, and teamwork.

Following Evaluation Components are suggested:

1. Activity 1- Group Presentation (20 marks)
2. Activity 2- Group Discussion (20 marks)
3. Classroom Participation and Engagement (10 marks)

Active participation in class discussions, group activities and question-answer sessions.

Sr. No.	Reference Books
1.	Chakravarthi T. Kalyana and Chakravarthi T. Latha, 2014, Soft Skills for Managers (Biztantra Publications, (ISBN: 978-81-7722-568-6)
2.	Kumar Sanjay and Pushp Lata, (2015), *Communication Skills*, 2nd Edition, Oxford University Press, (ISBN: 9780199457069)
3.	P. D. Chaturvedi and Mukesh Chaturvedi, (2017), The Art and Science of Business Communication- Skills, Concepts, Cases and Applications, 4th Edition, Pearson India Education Services Pvt. Ltd., (ISBN 978-93-325-8728-1)
4.	Wright. L., (2001), Critical Thinking: An Introduction to Analytical Reading and Reasoning. Oxford University Press.
5.	Kallet, M., (2014), Think Smarter: Critical Thinking to Improve Problem-Solving and Decision-

	Making Skills. Wiley.
6.	Bradberry, T., & Greaves, J., (2009), Emotional Intelligence 2.0. TalentSmart.
7.	Dweck, C. S., (2007), Mindset: The New Psychology of Success. Ballantine Books.

<table>
<tr><td>Year, Program, Semester</td><td colspan="5">S.Y. B. Tech (Chemical Engineering) , Part II ,Semester IV</td></tr>
<tr><td>Course Code</td><td colspan="5">PBL 221</td></tr>
<tr><td>Course Category</td><td colspan="5">Project Based Learning</td></tr>
<tr><td>Course title</td><td colspan="5">Mini Project II & Industrial Visit</td></tr>
<tr><td rowspan="2">Teaching Scheme and Credits</td><td>L</td><td>T</td><td>P</td><td>Total Contact Hours</td><td>Total Credits</td></tr>
<tr><td>-</td><td>01</td><td>-</td><td>01</td><td>00</td></tr>
<tr><td>Evaluation Scheme</td><td colspan="5">IE at the course in charge end.</td></tr>
<tr><td>Pre-requisites (if any)</td><td colspan="5">Thorough revision of all the courses studied till Semester III with a vigor to undertake small survey type of project work.</td></tr>
<tr><td>Course Rationale</td><td colspan="5">Mini Project II and Industrial Visit provide students with an opportunity to further develop and apply the knowledge and skills acquired in their previous coursework. It allows them to engage in hands-on experiential learning through project activities and real-world exposure gained from industrial visits. This course aims to bridge the gap between theoretical learning and practical application, fostering a deeper understanding of chemical engineering principles and practices in industrial settings.</td></tr>
<tr><td>Course Objectives</td><td colspan="5">The course teacher will
1. Enhance students' understanding of real-world chemical engineering processes through industrial visits.
2. Provide students with an opportunity to apply theoretical knowledge to practical projects effectively.
3. Develop students' skills in problem-solving, teamwork, and project management.
4. Encourage critical thinking and innovation in approaching engineering challenges.
5. Cultivate professional ethics and attitudes essential for the workplace environment.</td></tr>
<tr><td>Course Outcomes</td><td colspan="5">Upon completion of this course, students will be able to
1. Analyse and evaluate chemical engineering processes observed during industrial visits.
2. Apply theoretical concepts to practical projects, showcasing proficiency in problem-solving and decision-making.
3. Collaborate effectively with team members to achieve project objectives within specified timelines.
4. Demonstrate innovation and creativity in proposing solutions to engineering problems encountered during project activities.
5. Exhibit professional conduct and ethical behavior in interactions with industry professionals during industrial visits.</td></tr>
</table>

Course Outcome and Program Outcome Mapping

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO1	3	-	3	-	-	2	3	-	-	-	-	-
CO2	3	3	-	-	3	1	-	-	2	-	-	-
CO3	-	3	-	-	3	3	-	-	3	-	3	-
CO4	-	3	-	3	2	-	-	-	1	-	-	2
CO5	-	-	-	-	-	2	-	3	2	2	-	2

Level of Mapping as: Low 1, Moderate 2, High 3

Course Content

Mini Project II and Industrial Visit is a continuation of the experiential learning journey initiated in Semester III. Building upon the foundations laid in Mini Project I and the previous industrial visit, students will delve deeper into project activities related to their chosen area of interest within chemical engineering.

The course encompasses two main components:

1. Mini Project II: Students will continue their project activities from the preceding semester, further refining their research objectives, conducting experiments, analyzing data, and presenting findings. Emphasis will be placed on applying advanced concepts and techniques to address specific challenges or opportunities identified in the chosen project area.
2. Industrial Visit: Students will participate in guided tours to various industrial facilities relevant to chemical engineering. These visits offer firsthand exposure to industrial processes, technologies, and practices, allowing students to gain insights into real-world applications of theoretical concepts learned in the classroom. Through interactions with industry professionals, students will gain valuable perspectives on the challenges and opportunities present in the field of chemical engineering.

The course will be conducted over the duration of one tutorial hour per week, with additional time allocated for project work and industrial visits as necessary. Assessment will be based on project presentations, reports, and reflections on industrial visits, evaluating students' understanding, application, and integration of theoretical and practical knowledge in the field of chemical engineering.

Course Assessment Process	
The course assessment process will be similar to that mentioned under Mini Project I & Industrial Visit. The difference is that this course is an audit course unlike Mini Project I & Industrial Visit.	
Sr. No.	**Reference Books**
1.	Ray, M. S., (1998), Chemical Engineering Design Project: A Case Study Approach (2nd ed.). CRC Press.
2.	Turton, R., Bailie, R.C., Whiting, W.B., Shaeiwitz, J.A., & Bhattacharyya, D., (2013), Chemical Engineering Design Project: A Case Study Approach (2nd ed.). Prentice Hall.
3.	Goyal, M., & Choudhary, S.K., (2016), Industrial Visits and Study in Chemical Process Industries. IK International Publishing House Pvt. Ltd.
Sr. No.	**Useful Web link**
1.	https://youtu.be/IBV2bvZMaUs?si=J-REKtvd37hnwNaH
2.	https://youtu.be/ttpJGffMOT0?si=HsjgcNjk5PZvLOy9
3.	https://youtu.be/8GOuceevhXU?si=xZeqeI0o8JHNqyJB
4.	The students can search on you-tube for the following key words: 1. ” Chemical Engineering Mini Projects" 2. "Chemical Engineering Industrial Visits" 3. "Hands-on Projects for Chemical Engineers" 4."Industrial Visits in Chemical Process Industries"

Year, Program, Semester	S.Y. B.Tech (Chemical Engineering) , Part II , Semester IV				
Course Code	HSMEC 221				
Course Category	Humanities, Social Sciences, Management Environment				
Course title	**Environmental Studies**				
Teaching Scheme and Credits	**L**	**T**	**P**	**Total Contact Hours**	**Total Credits**
	02	-	-	02	00
Evaluation Scheme	Even Semester End Exam: 70 Marks, Project/Visit based IOE: 30 Marks.				
Pre-requisites (if any)	HSMEC 211				
Course Rationale	The Course is all about learning the way we should live and how we can develop sustainable strategies to protect the environment. It helps individuals to develop an understanding of living and physical environment and how to resolve challenging environmental issues affecting nature.				
Course Objectives	The course teacher will ensure to 1. Describe the various types and sources of environmental pollution. 2. Explore other global environmental issues, such as biodiversity loss, deforestation, and ocean acidification. 3. Explain key environmental laws and regulations at the national and international levels. 4. Explain the relationship between human society and the environment.				
Course Outcomes	Upon completion of this course, student should be able to 1. Classify different types of environmental pollutants and their sources. 2. Analyse the interconnections between climate change and other global environmental issues. 3. Understand the legal frameworks and regulations governing environmental protection and management. 4. Describe the socio-economic drivers of environmental degradation and inequality.				

Course Outcome and Program Outcome Mapping

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO1	3	3	-	-	-	-	3	3	-	-	-	-
CO2	-	3	3	3	-	-	3	3	3	2	-	-
CO3	-	2	3	3	-	-	3	3	3	3	-	-
CO4	-	2	-	-	-	-	3	3	3	3	-	-

Level of Mapping as: Low 1, Moderate 2, High 3

Unit No.	Course Content	Hours
I.	**Environmental Pollution:** Definition: Causes, effects and control measures of: a) Air pollution, b) Water pollution, c) Soil pollution, d) Marine pollution, e) Noise pollution, f) Thermal pollution, g) Nuclear hazards and their effects. Solid waste Management: Causes, effects and control measures of urban and industrial wastes. Role of an individual in prevention of pollution	**07**
II.	**Understanding climate change and other global environmental issues:** - Structure of atmosphere; greenhouse gas emissions; Projections of global climate change, Importance of 1.5 °C and 2.0 °C limits to global warming; Carbon foot print, -Impacts of climate change: on ocean and land systems; Sea level rise, changes in marine and coastal ecosystems; Impacts on forests and natural ecosystems; Impacts on animal species, agriculture, health, urban infrastructure; -Mitigation of climate change: Green House Gas (GHG) reduction, sink enhancement; Concept of carbon intensity, energy intensity and carbon neutrality; National and international policies for mitigation, net zero targets for the future; Energy efficiency measures; Renewable energy sources for carbon reduction; Carbon capture and storage, - Acid Rain: Causes, effects and mitigation - Ozone Layer Depletion: Causes, effects and mitigation.	**08**
III.	**Environmental legislation:** Introduction to environmental laws and regulation: Constitutional provisions- Article 48A, Article 51A (g), Environmental Protection Act., Air (Prevention and Control of Pollution) Act, Water (Prevention and control of Pollution) Act, Wildlife Protection Act, Forest Conservation Act	**06**
IV.	**Social Environment:** Environmental ethics, Environmental movements- Chipko Movement, Appiko Movement, Silent Valley Movement. Water conservation: rain water harvesting, watershed management, Disaster management: floods, earthquake, cyclone, tsunami and landslides.	**04**
	Nature Visits / Field Work /Field Tour/ Industrial visits / Activities related to Campus environmental management (5 Hrs.)	**05**

Sr. No.	Text Books
1.	Agarwal, K. C. (2001), Environmental Biology, Nidi Publ. Ltd., Bikaner.
2.	Bharucha Erach, The Biodiversity of India, Mapin Publishing Pvt. Ltd., Ahmedabad, 380013, India.
3.	Brunner R. C., (1989), Hazardous Waste Incineration, McGraw Hill Inc. 480p.
Sr. No.	**Reference Books**
1.	Cunningham, W. P. Cooper, T. H. Gorhani, E. & Hepworth, M. T.,(2001), Environmental Encyclopedia, Jaico Publ. House, Mumbai.
2.	Gleick, H., (1993), Water in crisis, Pacific Institute for Studies in Dev., Environment & Security. Stockholm Env. Institute. Oxford Univ. Press 473p.
3.	Hawkins R. e., Encyclopedia of Indian Natural History, Bombay Natural History Society, Bombay (R).
4.	Heywood, V. H. & Watson, R. T., (1995), Global Biodiversity Assessment, Cambridge Univ. Press.
5.	Jadhav, H. & Bhosale, V. M., (1995), Environmental Protection and Laws, Himalaya Pub.

	House, Delhi, 284p.
6.	Mckinney, M. L. & Schocl. R. M., (1996), Environmental Science Systems & Solutions, Web enhanced edition.
7.	Miller T. G. Jr., Environmental Science, Wadsworth Publishing Co. (TB).
8.	Odum, E. P., (1971), Fundamentals of Ecology, W. B. Saunders Co. USA.
9.	Rao M. N. & Datta, A. K., (1987), Waste Water Treatment, Oxford & IBH Publ. Co. Pvt. Ltd.,
10.	Sharma B. K., (2001), Environmental Chemistry, Goel Publ. House, Meerut.
11.	Survey of the Environment, The Hindu (M).
12.	Trivedi R. K., Handbook of Environmental Laws, Rules, Guidelines, Compliances and Standards, Vol. I and II, Enviro Media (R)
13.	Wagner K. D., (1998), Environmental Management, W. B. Saunders Co. Philadelphia, USA.

Equivalence for the curriculum revision at B. Tech Chemical Engineering

The above curriculum structure is a revised version of the Second Year B. Tech (Chemical Engineering) Program being conducted by Shivaji University at its Technology Department. A special mention rather feature of this revision is, ***it is aligned with New National Education Policy 2020 guidelines, and also it follows the directives of NHEQF & National Credit Framework.*** This curriculum is to be implemented from July 2024, (Academic year 2024-25).

The Equivalence for the Courses of Chemical Engineering at Second Year B Tech Semester III and IV pre-revised Program under the faculty of Science and Technology is as follows.

SEM – III

Sr. No.	Second Year B. Tech Semester III Pre-revised syllabus	Second Year B. Tech Semester III Revised syllabus	Remark
1.	Chemistry-I (Theory & Lab)	Applied Chemistry-I (Physical, Inorganic& Analytical) (Theory & Lab)	Content is revised, title is changed.
2.	Chemical Engineering Thermodynamics-I	Chemical Engineering Thermodynamics	Clubbed in a single course with content revision.
3.	Engineering Mathematics-III	Engineering Mathematics-III	Content is revised.
4.	Chemical Process Calculations	-	Shifted to next semester.
5.	-	Material Science & Engineering	Shifted from next Semester.
6.	Fluid Flow Operations (Theory & Lab)	Fluid Flow Operations (Theory & Lab)	Content is revised
7.	Computer Programming for ChemicalEngineers (Theory & Lab)	-	Taken care in open electives listing.
8.	Analytical Chemistry Laboratory (Lab)	-	Clubbed in other course.
9.	Environmental Studies	Environmental Studies	Modified as per University prescribed content. But there are no credits. End Semester Evaluation is Split into two semesters.
10.	Soft Skills Development	Soft Skills Development	Content is revised and made it as a Credit course
11.	-	Mini Project I & Industrial Visit	Newly introduced audit course.

SEM – IV

Sr. No.	Second Year B. Tech Semester IV Pre-revised syllabus	Second Year B. Tech Semester IV Revised syllabus	Remark
1.	Chemistry-II (Theory & Lab)	Applied Chemistry-II (Organic) (Theory & Lab)	Title change with content revision
2.	Chemical Engineering Thermodynamics-II	-	Clubbed in a single course.
3.	Material Science & Technology	-	Shifted to previous semester.
4.	Heat Transfer Operations (Theory & Lab)	Heat Transfer Operations (Theory & Lab)	Content is revised.
5.	Introduction to Performing Arts	Introduction to Performing Arts	Made it as a Credit course with content revision.
6.	Mechanical Operations (Theory & Lab)	Mechanical Operations (Theory & Lab)	Content is revised.
7.	Applied Electrical & Electronics Theory,Laboratory (Lab)	-	Taken care in list of open electives.
8.	-	Inorganic Chemical Technologies	Shift of semester from TY B. Tech
9.	-	Chemical Process Calculations	Shifted from previous semester.
10.	-	Multidisciplinary Minor Course I	As per NEP feature, MDM is introduced.
11.	-	Aptitude Enhancement Course I	Newly introduced audit course.
12.	Mini Project	Mini Project II & Industrial Visit	Newly added audit course.
13.	-	Environmental Studies	Modified as per University prescribed. But there are no credits. End Semester Evaluation is Split into two semesters.

Shivaji University,
Vidyanagar, Kolhapur, Maharashtra- 416 004

Department of Technology

As per NEP2020 guidelines

Pool of Multidisciplinary Minors for
MDM Featured B. Tech (Chemical Engineering), Detailed Curriculum

S

Multidisciplinary Minor
In
Food Process Engineering
For
B.Tech (Chemical Engineering)

Shivaji University, Kolhapur

Department of Technology

Multidisciplinary Minor in Food Process Engineering

Teaching & Evaluation Scheme

Sr. No.	Category	Course Code	Course Title	Hours per week			Contact Hours	Credits	Evaluation Scheme	
									Theory	Practical
				L	T	P			ISE:ESE	IE:EE
1.	Preferably on SWAYAM (NPTEL) or any other MOOCs (Minor Program Core) Or In a Face-to-Face mode	MDM 1.1	Food Chemistry & Biochemistry	03	-	-	03	03	30:70	00:00
2.		MDM 1.2	Food Engineering	03	-	-	03	03	30:70	00:00
3.		MDM 1.3	Food Laws & Standard	03	-	-	03	03	30:70	00:00
4.	Program Based Internship	MDM 1.4	Food Industry Internship	One Month				03	-	50:50
5.	Project Based Learning	MDM 1.5	Mini Project	-	-	-	-	02	-	50:50
				-	**-**	**-**	**-**	**14**	**300**	**200**
			Total Hours	**09**	**00**	**00**	**09**	**-**	**-**	**-**

Note: MDM Program's Internship and Mini Project need to be planned during winter or summer vacation days after 4th semester while respective evaluations will be the part of 7th and 8th Semesters of the B.Tech. Major structure.

Multidisciplinary Minor I : Food Process Engineering

Year, Program, Semester	Multidisciplinary Minor I , 4th Semester Onwards							
Course Code	MDM-1.1							
Course Category	Minor Program Core							
Course Title	**Food Chemistry & Biochemistry**							
Teaching Scheme and Credits	L	T	P	Total Contact Hours		Total Credits		
	03	-		03		03		
Evaluation Scheme	ISE		ESE	IOE	IPE	EOE	EPE	Total
	30		70	-	-	-	-	100
Pre-requisites(if any)	Basic understanding of chemistry and biology concepts.							
Course Rationale	This course introduces students to the fundamental principles of food chemistry and biochemistry, providing essential knowledge for understanding the composition, properties, and transformations of food components crucial for careers in food science, nutrition, and related fields.							
Course Objectives	The Course Teacher will 1. Explain the chemical composition and structure of macronutrients andmicronutrients in food. 2. Describe the role of enzymes and biochemical reactions in food processing and preservation. 3. Discuss the chemical and physical changes that occur during food preparation, cooking, and storage. 4. Illustrate the biochemical processes involved in digestion, absorption,and metabolism of nutrients in the human body. 5. Elaborate the impact of food chemistry and biochemistry on food quality, safety, and nutrition. 6. Explore chemical and biochemical principles to solve problems relatedto food science and technology.							
Course Outcomes	Upon completion of this course, student should be able to 1. Understand the chemical composition and structure of macronutrientsand micronutrients in food. 2. Explain the role of enzymes and biochemical reactions in food processing and preservation. 3. Analyze the chemical and physical changes that occur during food preparation, cooking, and storage. 4. Describe the biochemical processes involved in digestion, absorption,and metabolism of nutrients in the human body. 5. Evaluate the impact of food chemistry and biochemistry on food quality,safety, and nutrition. 6. Apply chemical and biochemical principles to solve problems related tofood science and technology.							

Course Outcome and Program Outcome Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO 12
CO 1	3	3	2	-	-	-	-	-	-	-	1	-
CO 2	3	2	2	-	-	-	-	-	-	-	1	-
CO 3	3	3	2	-	-	-	-	-	-	-	1	-
CO 4	3	2	2	-	-	-	-	-	-	-	1	-
CO 5	3	3	2	-	-	-	-	-	-	-	1	-
CO 6	3	3	2	-	-	-	-	-	-	-	1	-

Level of Mapping as: Low 1, Moderate 2, High 3

Unit No.	Course Content	Hours
I	**Introduction to Food Chemistry** Overview of food chemistry and its importance in the food industry, Basic chemical composition of food: carbohydrates, lipids, proteins, vitamins, minerals, and water., Chemical reactions involved in food processing and cooking., Principles of food additives and preservatives, Importance of pH and water activity in food chemistry, Introduction to food analysis techniques.	06
II	**Carbohydrates in Foods** Structure and classification of carbohydrates, Functions of carbohydrates in food systems. Starches: types, properties, and uses in Food, Sugars: sources, sweetness, and caramelization, Dietary fiber: types, benefits, and effects on food texture, Maillard reaction and its significance in food chemistry**.**	06
III	**Lipids in Foods** Structure and classification of lipids, Functions of lipids in food systems: energy source, texture, flavor, and mouthfeel, Fats and oils: sources, composition, and properties, Oxidative rancidity and methods of lipid oxidation prevention, Emulsions: formation, stabilization, and applications in food, Trans fats and their impact on health.	06
IV	**Introduction to Biochemistry** Overview of biochemistry and its significance in living organisms, Basic chemical elements and bimolecular in living systems, Structure and function of bimolecular: proteins, carbohydrates, lipids, nucleic acids, Principles of enzyme catalysis and Regulation, Metabolism: anabolism and catabolism, energy pathways, Introduction to bioinformatics and molecular biology techniques.	07
V	**Proteins and Enzymes** Structure and function of proteins: primary, secondary, tertiary, and quaternary structures, Protein denaturation and renaturation, Enzyme kinetics: Michaelis-Menten equation, enzyme-substrate interaction, Factors affecting enzyme activity: temperature, pH, substrate concentration, Regulation of enzyme activity: allosteric regulation, covalent modification, Enzyme inhibition: competitive, non-competitive, and irreversible inhibition.	07
VI	**Metabolism and Bioenergetics** Overview of cellular metabolism: glycolysis, citric acid cycle, oxidative Phosphorylation, Role of ATP as the energy currency of the cell, Metabolic pathways: gluconeogenesis, glycogen metabolism, fatty acid metabolism, Regulation of metabolism: hormonal control, feedback inhibition, Metabolism of nitrogenous	07

	compounds: amino acid metabolism, urea cycle, Bioenergetics of photosynthesis: light reactions, Calvin cycle, carbon fixation.	
Text Books		
1.	Jay, J. M., Loessner, M. J., & Golden, D. A. (Eds.). (2005). Modern Food Microbiology (7th ed.). Springer.	
2.	Doyle, M. P., & Buchanan, R. L. (Eds.). (2013). Food Microbiology: Fundamentals and Frontiers (4th ed.). ASM Press.	
3.	Adams, M. R., & Moss, M. O. (2008). Food Microbiology (3rd ed.). Royal Society of Chemistry.	
4.	Ray, B., & Bhunia, A. K. (2017). Fundamental Food Microbiology (5th ed.). CRC Press.	
Reference Books		
1.	Montville, T. J., & Matthews, K. R. (Eds.). (2008). Food Microbiology: An Introduction (2nd ed.). ASM Press.	
2.	Sofos, J. N. (Ed.). (2014). Food Microbiology: Fundamentals and Applications. Springer.	

Year, Program, Semester	Multidisciplinary Minor I, 4th Semester Onwards							
Course Code	MDM 1.2							
Course Category	Minor Program Core							
Course Title	**Food Engineering**							
Teaching Scheme and Credits	**L**	**T**	**P**	**Total Contact Hours**			**Total Credits**	
	03	-		03			03	
Evaluation Scheme	**ISE**	**ESE**		**IOE**	**IPE**	**EOE**	**EPE**	**Total**
	30	70		-	-	-	-	100
Pre-requisites(if any)	Basic knowledge of chemistry, physics, and engineering principles.							
Course Rationale	This course would focus on the engineering principles applied to food processing, including unit operations such as heat transfer, mass transfer, fluid flow, and separation processes. Students would learn about food preservation methods, food packaging, and the design of food processing equipment.							
Course Objectives	The Course Teacher will 1. Explain food engineering fundamentals. 2. Enlist methods for food preservation. 3. Demonstrate principles of food packaging materials. 4. Describe principles and equipment in processing. 5. Explain rheological properties of food. 6. Elaborate emerging trends and technologies.							
Course Outcomes	Upon completion of this course, student should be able to 1. Apply mass and energy balances in processing. 2. Evaluate techniques for extending shelf-life. 3. Design effective packaging solutions for products. 4. Analyze and optimize food processing operations. 5. Analyze texture and its sensory evaluation 6. Apply innovative solutions to food engineering challenges.							

Course Outcome and Program Outcome Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO 12
CO 1	3	3	2	-	-	-	-	-	-	-	1	-
CO 2	3	2	2	-	-	-	-	-	-	-	1	-
CO 3	3	3	2	-	-	-	-	-	-	-	1	-
CO 4	3	2	2	-	-	-	-	-	-	-	1	-
CO 5	3	3	2	-	-	-	-	-	-	-	1	-
CO 6	3	3	2	-	-	-	-	-	-	-	1	-

Level of Mapping as: Low 1, Moderate 2, High 3

Unit No.	Course Content	Hours
I	**Introduction** Fundamentals of food engineering principles and their application in food Processing, Overview of food properties, composition, and quality factors Introduction to food preservation techniques such as pasteurization, sterilization, and dehydration.	06
II	**Heat Transfer in Food Processing** Heat transfer mechanisms and their applications in food processing operations, Thermal properties of foods and their influence on heat transfer processes, Heat exchanger designand analysis for food processing applications.	06
III	**Rheological Properties of Food** Introduction to rheology, viscosity, viscoelasticity, and rheological behavior of food materials, Texture Analysis: Principles of texture measurement, texture profile analysis, and its applications in food processing and quality control.	06
IV	**Packaging Materials, Technologies & Food Storage** Types of packaging materials (plastics, glass, metals, paper) and their properties, Packaging Technologies: Packaging machinery, packaging design, and packaging materials interactions, Food Storage- Principles of food storage, factors affecting food shelf-life, and storage technique.	06
V	**Food Process Engineering** Food Drying: Principles of drying, drying kinetics, and types of dryers used in food processing, Food Extrusion: Basics of extrusion processing, equipment, and applications in food production, Food Fermentation: Principles of fermentation, microbial cultures and their applications in food processing.	06
VI	**Advanced Topics in Food Engineering** Food Nanotechnology: Introduction to nanotechnology, applications in food packaging, delivery systems, and sensors, Food Process Modeling and Simulation: Basics of mathematical modeling, simulation techniques, and their applications in food process optimization, Emerging Technologies in Food Engineering: Introduction to novel technologies such as high-pressure processing, pulsed electric field processing, and their potential applications in food processing.	06
Text Books		
1.	Singh, R. P., Heldman, D. R., & Singh, R. P. (2016). Introduction to Food Engineering (5th ed.). Academic Press.	
2.	Potter, N. N., & Hotchkiss, J. H. (2017). Food Science (7th ed.). Springer.	
3.	Smith, P., & Hui, Y. H. (Eds.). (2018). Food Processing: Principles and Applications. Wiley-Blackwell.	
4.	Fellows, P. (2016). Food Processing Technology: Principles and Practice (4th ed.). Woodhead Publishing.	
Reference Books		
1.	Barbosa-Cánovas, G. V., & Fontana, A. J. (Eds.). (2017). Engineering Aspects of Thermal Food Processing (2nd ed.). CRC Press.	
2.	Richardson, P., & Wijesundera, C. (Eds.). (2017). Food Rheology: Principles, Measurement, and Applications. Woodhead Publishing	

Year, Program, Semester	Multidisciplinary Minor I, 4th Semester onwards							
Course Code	MDM 1.3							
Course Category	Minor Program Core							
Course Title	**Food Laws and Standards**							
Teaching Scheme and Credits	L	T	P	Total Contact Hours			Total Credits	
	03	-		03			03	
Evaluation Scheme	ISE	ESE		IOE	IPE	EOE	EPE	Total
	30	70		-	-	-	-	100
Pre-requisites(if any)	Basic understanding of food science and food processing principles.							
Course Rationale	This course is aimed to make students understand food laws and standards which is essential for ensuring compliance, safety, and quality in the food industry, addressing global regulatory frameworks critical for food production, trade, and public health.							
Course Objectives	The Course Teacher will 1. Explain the historical development and significance of food laws. 2. Discuss key provisions of FSMA and HACCP. 3. Describe requirements for food labeling and packaging. 4. Elaborate approval process for food additives. 5. Illustrate sensory, physical, and chemical quality parameters. 6. Elaborate strategies for regulatory compliance.							
Course Outcomes	Upon completion of this course, student should be able to 1. Identify the role of regulatory agencies in food regulation. 2. Analyze compliance challenges in food safety regulations. 3. Evaluate compliance with labeling and packaging regulations. 4. Assess safety and suitability of novel food ingredients. 5. Implement quality assurance programs in food production. 6. Identify consequences of non-compliance and legal remedies.							

Course Outcome and Program Outcome Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO 12
CO 1	3	3	2	-	-	-	-	-	-	-	1	-
CO 2	3	2	2	-	-	-	-	-	-	-	1	-
CO 3	3	3	2	-	-	-	-	-	-	-	1	-
CO 4	3	2	2	-	-	-	-	-	-	-	1	-
CO 5	3	3	2	-	-	-	-	-	-	-	1	-
CO 6	3	3	2	-	-	-	-	-	-	-	1	-

Level of Mapping as: Low 1, Moderate 2, High 3

Unit No.	Course Content	Hours
I	**Introduction to Food Laws and Regulations** Overview of Food Laws: Historical development and significance, Regulatory Agencies: Role of government agencies (FDA, USDA, etc.) in food regulation, Global Food Standards, Introduction to international organizations (Codex Alimentarius, WTO) and their impact on food regulation.	06
II	**Food Safety Regulations** Food Safety Modernization Act (FSMA): Overview and key provisions, Hazard Analysis and Critical Control Points (HACCP): Principles and implementation. Good Manufacturing Practices (GMPs) and Sanitation Standard Operating Procedures (SSOPs): Requirements and enforcement.	06
III	**Labeling and Packaging Regulations** Labeling Requirements: Nutritional Labeling: Mandatory components including serving size, calories, nutrients, and percent daily values, Ingredient Lists: Requirements for listing ingredients in descending order of predominance by weight, Allergen Labeling: Regulations for declaring major food allergens and requirements for precautionary allergen labelling, Country of Origin Labeling (COOL): Requirements for identifying the origin of certain foods. Fair Packaging and Labeling Act (FPLA) Objectives and scope of FPLA in ensuring accurate and informative labeling.	06
IV	**Food Additives and Ingredients Regulations** Food Additives: Definition and classification of food additives: Colors, flavors, preservatives, antioxidants, emulsifiers, and sweeteners, Approval process for food additives: Submission of petitions, safety evaluations, and regulatory review. Novel Food Ingredients: Regulatory oversight of novel food ingredients including genetically modified organisms (GMOs) and bioengineered foods.	06
V	**Food Quality Standards** Food Quality Attributes: Sensory, physical, and chemical quality parameters, Food Grading Systems: Voluntary and mandatory grading systems for various commodities. Quality Assurance and Quality Control Programs: Implementation and monitoring of Quality standards.	06
VI	**Compliance and Enforcement** Regulatory Compliance: Strategies for meeting regulatory requirements, Inspections and Audits: Procedures for regulatory inspections and audits, Enforcement Actions: Consequences of non-compliance and legal remedies.	06

	Text Books
1.	Hagen, J., & Coombs, J. (2015). Food Law and Regulation for Non-Lawyers: A US Perspective. Springer.
2.	Belton, P. (2014). Food Law in the United States. Cambridge University Press.
3.	Stein, A. J., & Cadieux, K. V. (2017). Food Regulation: Law, Science, Policy, and Practice. Wiley.
4.	Roberts, P., & Robinson, J. (2013). Food Law in the United Kingdom. Bloomsbury Professional
	Reference Books
1.	Gray, M. L., & Eggleston, S. (Eds.). (2019). Food Law in the United States. Wolters Kluwer Law & Business.
2.	Beale, S. S., & Mares, M. (2019). Principles of Food Law. Routledge

Year, Program, Semester	Multidisciplinary Minor I, 4th Semester onwards						
Course Code	MDM 1.4						
Course Category	Program Based Internship						
Course Title	**Food Industry Internship**						
Teaching Scheme and Credits	**L**	**T**	**P**	**Total Contact Hours**	**Total Credits**		
	One Month				03		
Evaluation Scheme	**ISE**	**ESE**	**IOE**	**IPE**	**EOE**	**EPE**	**Total**
	00	00	50	-	50	-	100
Pre-requisites(if any)	Basics of unit processes and unit operations.						
Course Rationale	The course caters specifically to B.Tech Chemical Engineering students as the part of multidisciplinary Minor in in areas such as Food Process Engineering. This course offers practical exposure to industry settings aligned with their chosen discipline, aiming to bridge the gap between theoretical knowledge and practical application. By engaging in a one-month internship, students gain firsthand experience, essential skills, and insights crucial for their future careers in additional sector of industry.						
Course Objectives	The course teacher will 1. Help expose students to the 'real' working environment; 2. Promote hands-on experience to the students' in their related field; 3. Develop synergetic collaboration between industry and the university in promoting a knowledgeable society; 4. Assist in providing the opportunity for students to test their interest in a particular career before permanent commitments are made. 5. Elaborate the dynamic and challenging nature of industrial environments.						
Course Outcomes	Upon completion of this course, student should be able to 1. Understand industrial processes and operations related to their minor sub-specializations. 2. Apply theoretical concepts to solve practical problems in the industry. 3. Communicate effectively with industry professionals, colleagues, and supervisors. 4. Collaborate efficiently in team environments to complete tasks and projects. 5. Adapt to the dynamic and challenging nature of industrial environments. 6. Reflect on internship experiences for personal and professional growth.						

Course Outcome and Program Outcome Mapping

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	-	-	-	-	-	-	-	-	-	-	-
CO 2	-	3	2	-	-	-	-	-	-	-	-	-
CO 3	-	-	-	-	-	-	-	-	-	3	-	-

CO4	-	-	-	-	-	-	-	-	3	-	-	-
CO5	-	-	-	-	-	2	-	-	-	-	-	3
CO6	-	-	-	-	-	-	-	-	-	-	-	2

Level of Mapping as: Low 1, Moderate 2, High 3

Course Content	Hours
The course consists of a one-month internship in Food Industry. Students will be placed in companies or organizations that align with the particular sector. During the internship, students will engage in various activities, including but not limited to: 1. Shadowing industry professionals to observe and learn about different processes and operations. 2. Assisting with ongoing projects or research initiatives within the organization. 3. Participating in hands-on tasks related to their minor sub-specialization, under the guidance of experienced mentors. 4. Attending training sessions, workshops, and seminars conducted by the industry to enhance their knowledge and skills. 5. Engaging in discussions and meetings with supervisors and colleagues to gain insights into industry practices, challenges, and innovations. 6. Documenting their internship experience through reports, presentations, or reflective journals. The period of one month for this internship will be during the winter or summer vacations, any such slots 4th Semester onwards.	4 weeks

Course Evaluation Method

This particular evaluation will be the part of the structure of 7th Semester.

The evaluation for the Industrial Internship course will be conducted as follows:

- **Internal Evaluation (50 marks):**
    - Assessment by course teachers based on students' performance during the internship, including attendance, participation, attitude, and contribution to assigned tasks.
    - Evaluation by industrial supervisors on students' professional conduct, technical skills, problem-solving abilities, and overall performance in the workplace.
- **External Evaluation (50 marks):**
    - Evaluation by an external examiner appointed by the institute, who will assess students' internship reports, presentations, or any other documentation submitted at the end of the internship period.
    - The external examiner will review the quality of students' reflections on their internship experience, their ability to apply theoretical knowledge to practical situations, and the depth of their understanding of industry practices and challenges.

The final grades for the Industrial Internship course will be determined based on the combined

assessment from both internal and external evaluations.	
Reference Books	
1.	Fellows, P. J. (2016). Food Process Engineering and Technology.
2.	Heldman, D. R., & Hartel, R. W. (2011). Principles of Food Processing.

Year, Program, Semester	Multidisciplinary Minor I, 4th Semester onwards						
Course Code	MDM 1.5						
Course Category	Project Based Learning						
Course Title	**Mini Project**						
Teaching Scheme and Credits	**L**	**T**	**P**	**Total Contact Hours**		**Total Credits**	
	-	-	-	-		02	
Evaluation Scheme	**ISE**	**ESE**	**IOE**	**IPE**	**EOE**	**EPE**	**Total**
	00	00	50	-	50	-	100
Pre-requisites(if any)	Basics of unit processes and unit operations.						
Course Rationale	This course aims to provide students with practical exposure and hands-on experience in real-world industrial settings, fostering a deeper understanding of theoretical concepts through application. By engaging in this field project, students will develop essential skills such as problem-solving, teamwork, and communication, preparing them for future challenges in the professional arena in the Food Industry.						
Course Objectives	The course teacher will 1. Facilitate application of theoretical knowledge. 2. Guide the students about enhancement of practical skills. 3. Explain about development of industry-relevant competencies.						
Course Outcomes	Upon completion of this course, student should be able to 1. Demonstrate application of theoretical concepts with instructor guidance. 2. Collaborate effectively in instructor-led team-based projects. 3. Communicate findings and insights professionally under instructor supervision.						

Course Outcome and Program Outcome Mapping

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	2	-	-	2	-	-	-	2	-	-	-
CO 2	-	-	3	-	-	-	-	-	3	-	2	1
CO 3	-	-	-	-	-	-	-	-	-	3	-	2

Level of Mapping as: Low 1, Moderate 2, High 3

Course Content

Minor Program Based Mini Project is a dynamic course designed to bridge the gap between classroom learning and real-world application. All the students will engage themselves in a series of tasks and challenge that will enable them to apply theoretical concepts learned in previous courses to solve practical problems. The project work need to be carried out independently covering a range of topics relevant to their field of study, allowing them to explore different facets of the particular discipline and develop versatile skill sets.

This activity may be planned after 4th Semester and can be completed prior to 8th Semester of their Major studies.

Course Assessment Process

This particular evaluation will be the part of 8th Semester of the major structure.

The course evaluation for the internals will be at the course teacher end while there will also be the external evaluation of the Project work.

The teachers will follow the instructions as below:

Evaluation Format: The evaluation may be conducted using a combination of assessment methods, including:

- Rubric-based assessment for the project work and its report.
- Peer evaluation for project.
- Instructor-led discussions or presentations to evaluate communication skills and critical thinking.
- Overall course grading based on a weighted average of individual assessments and participation.

The evaluation format should be transparent, fair, and aligned with the course objectives and outcomes. Regular feedback and communication with students will ensure that the evaluation process remains supportive of their learning journey.

Multidisciplinary Minor
In
Artificial Intelligence and Machine Learning

For
B.Tech (Chemical Engineering)

Shivaji University, Kolhapur

Department of Technology

Multidisciplinary Minor in Artificial Intelligence and Machine Learning

Teaching & Evaluation Scheme

Sr. No.	Category	Course Code	Course Title	Hours per week			Contact Hours	Credits	Evaluation Scheme	
									Theory	Practical
				L	T	P			ISE:ESE	IE:EE
1.	Preferably on SWAYAM (NPTEL) or any other MOOCs (Minor Program Core) Or In a Face-to-Face mode	MDM 2.1	Introduction to AI & Machine Learning	03	-	-	03	03	30:70	00:00
2.		MDM 2.2	Introduction to Data Analytics	03	-	-	03	03	30:70	00:00
3.		MDM 2.3	Deep Learning and Neural Network	03	-	-	03	03	30:70	00:00
4.	Program Based Internship	MDM 2.4	AI ML Related Internship	One Month			-	03	-	50:50
5.	Project Based Learning	MDM 2.5	Mini Project	-	-	-	-	02	-	50:50
				-	-	-	-	14	300	200
			Total Hours	09	00	00	09	-	-	-

Note: MDM Program's Internship and Mini Project need to be planned during winter or summer vacation days after 4th semester while respective evaluations will be the part of 7th and 8th Semesters of the B.Tech Major structure.

Multidisciplinary Minor II: Artificial Intelligence and Machine Learning

Year, Program, Semester	Multidisciplinary Minor II , 4th Semester Onwards												
Course Code	MDM-2.1												
Course Category	Minor Program Core												
Course title	**Introduction to AI & Machine Learning**												
Teaching Scheme and Credits	**L**	**T**	**P**	**Total Contact Hours**				**Total Credits**					
	03	-	-	03				03					
Evaluation Scheme	ISE		ESE	IOE		IPE		EOE		EPE		Total	
	30		70	-		-		-		-		100	
Pre-requisites(if any)	Mathematical concepts such as statistics, calculus, probability, and linear algebra.												
Course Objectives	The Course is aimed to 1. Review and strengthen important mathematical concepts required for AI &ML. 2. Introduce the concept of learning patterns from data and develop a strong theoretical foundation for understanding state of the art Machine Learning algorithms.												
Course Outcomes	Upon completion of this course, student should be able to 1. Design and implement machine learning solutions to classification, regression and clustering problems. 2. Evaluate and interpret the results of the different ML techniques. 3. Design and implement various machine learning algorithms in a range of Real-world applications.												

Course Outcome and Program Outcome Mapping

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	2	-	-	3	-	-	-	-	-	-	-
CO 2	2	-	2	-	3	-	-	-	-	-	-	-
CO 3	-	-	2	-	2	-	-	-	-	-	-	-

Level of Mapping as: Low 1, Moderate 2, High 3

Unit No.	Course Content	Hours
I	Defining Artificial Intelligence, Defining AI techniques, Using Predicate Logic and Representing Knowledge as Rules, Representing simple facts in logic, Computable functions and predicates, Procedural vs Declarative knowledge, Logic Programming, Mathematical foundations: Matrix Theory and Statistics for Machine Learning.	**09**
II	Idea of Machines learning from data, Classification of problem –Regression and Classification, Supervised and Unsupervised learning.	**08**

III	Linear Regression: Model representation for single variable, Single variable Cost Function, Gradient Decent for Linear Regression, Gradient Decent in practice.	**08**
IV	Logistic Regression: Classification, Hypothesis Representation, Decision Boundary, Cost function, Advanced Optimization, Multi-classification (One vs All), Problem of Overfitting.	**08**
V	Discussion on clustering algorithms and use-cases cantered around clustering and classification.	**06**

Text / Reference Books

1.	Saroj Kaushik, Artificial Intelligence, Cengage Learning, 1st Edition 2011
2.	Anindita Das Bhattacharjee, "Practical Workbook Artificial Intelligence and Soft Computing for beginners, Shroff Publisher-X team Publisher.
3.	Yuxi (Hayden) Liu, "Python Machine Learning by Example", Packet Publishing Limited, 2017.
4.	Tom Mitchell, Machine Learning, McGraw Hill, 2017.
5.	Christopher M. Bishop, Pattern Recognition and Machine Learning, Springer, 2011.
6.	T. Hastie, R. Tibshirani, J. Friedman. The Elements of Statistical Learning, 2e, 2011.

Note: Though it's a theory course, there will be classes on computers for hands on practice. The activity content for the same is as follows.

- Implementation of logical rules in Python
- Using any data apply the concept of: Liner regression, Gradient decent, Logistic regression
- To add the missing value in any data set.
- Perform and plot under fitting and overfitting in a data set.
- Implementation of clustering and classification algorithms.

Year, Program, Semester	Multidisciplinary Minor II , 4th Semester Onwards							
Course Code	MDM-2.2							
Course Category	Minor Program Core							
Course title	**Introduction to Data Analytics**							
Teaching Scheme and Credits	**L**	**T**	**P**	**Total Contact Hours**		**Total Credits**		
	03	-	-	03		03		
Evaluation Scheme	ISE		ESE	IOE	IPE	EOE	EPE	Total
	30		70	-	-	-	-	100
Pre-requisites(if any)	Solid foundation in basic mathematics, including algebra, calculus, and probability.							
Course Objectives	The Course is aimed to 1. Provide the knowledge and expertise to become a proficient data scientist. 2. Demonstrate an understanding of statistics and machine learning concepts that are vital for data science. 3. Produce Python code to statistically analyses a dataset. 4. Critically evaluate data visualizations based on their design and use for communicating stories from data.							
Course Outcomes	Upon completion of this course, student should be able to 1. Explain how data is collected, managed and stored for data science. 2. Understand the key concepts in data science, including their real- world applications and the toolkit used by data scientists. 3. Implement data collection and management scripts using MongoDB.							

Course Outcome and Program Outcome Mapping

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	-	-	-	3	-	-	-	-	-	-	-	-
CO 2	-	-	-	-	3	-	-	-	-	-	-	-
CO 3	-	-	2	2	-	-	-	-	-	-	-	-

Level of Mapping as: Low 1, Moderate 2, High 3

Unit No.	Course Content	Hours
I	Introduction to Data Science, Different Sectors using Data science, Purpose and Components of Python in Data Science.	**07**
II	Data Analytics Process, Knowledge Check, Exploratory Data Analysis (EDA), EDA-Quantitative technique, EDA- Graphical Technique, Data Analytics Conclusion and Predictions.	**07**
III	Feature Generation and Feature Selection (Extracting Meaning from Data)- Motivating application: user (customer) retention- Feature Generation (brainstorming, role of domain expertise, and place for imagination)- Feature Selection algorithms.	**09**
IV	Data Visualization- Basic principles, ideas and tools for data visualization, Examples of inspiring (industry) projects- Exercise: create your own visualization of a complex dataset.	**09**

V	Applications of Data Science, Data Science and Ethical Issues- Discussions on privacy, security, ethics- A look back at Data Science- Next-generation data scientists.	**07**

Text / Reference Books	
1.	Joel Grus, Data Science from Scratch, Shroff Publisher /O'Reilly PublisherMedia.
2.	Annalyn Ng, Kenneth Soo, Numsense! Data Science for the Layman, Shroff Publisher.
3.	Cathy O'Neil and Rachel Schutt. Doing Data Science, Straight Talk from The Frontline. O'Reilly Publisher Media.
4.	Jure Leskovek, Anand Rajaraman and Jeffrey Ullman. Mining of Massive Datasets. v2.1, Cambridge University Press.
5.	Jake VanderPlas, Python Data Science Handbook, Shroff Publisher 'Reilly Publisher Media.
6.	Philipp Janert, Data Analysis with Open Source Tools, Shroff Publisher /O'Reilly Publisher Media.

Note: Though it's a theory course, there will be classes on computers for hands on practice. The activity content for the same is as follows.

- Python Environment setup and Essentials.
- Mathematical computing with Python (NumPy).
- Scientific Computing with Python (SciPy).
- Data Manipulation with Pandas.
- Prediction using Scikit-Learn.
- Data Visualization in python using matplotlib.

Year, Program, Semester	Multidisciplinary Minor II , 4th Semester Onwards						
Course Code	MDM-2.3						
Course Category	Minor Program Core						
Course title	**Deep Learning and Neural Network**						
Teaching Scheme and Credits	**L**	**T**	**P**	**Total Contact Hours**		**Total Credits**	
	03	-	-	03		03	
Evaluation Scheme	ISE	ESE	IOE	IPE	EOE	EPE	Total
	30	70	-	-	-	-	100
Pre-requisites(if any)	Basic Mathematics, matrix arithmetic, probability.						
Course Objectives	The Course is aimed to 1. Strengthen important Mathematical concepts required for Deep learning and neural network. 2. Get a detailed insight of advanced algorithms of neural networks. 3. Introduce different deep learning network.						
Course Outcomes	Upon completion of this course, student should be able to 1. Design and implement Artificial Neural networks. 2. Decide when to use which type of NN. 3. Implement and analyze various deep learning architectures.						

Course Outcome and Program Outcome Mapping

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	-	-	2	-	2	-	-	-	-	-	-	-
CO 2	-	2	-	-	2	-	-	-	-	-	-	-
CO 3	-	2	3	-	3	-	-	-	-	-	-	-

Level of Mapping as: Low 1, Moderate 2, High 3

Unit No.	Course Content	Hours
I	Information flow in a neural network, understanding basic structure and ANN	**08**
II	Training a Neural network, how to determine hidden layers, recurrent neural network	**08**
III	Convolutional neural networks, image classification and CNN.	**08**
IV	RNN and LSTMs. Applications of RNN in real world.	**08**
V	Creating and deploying networks using tensor flow and keras	**07**

Text / Reference Books

1.	John Paul Mueller, Luca Massaron, Deep Learning for Dummies, John Wiley & Sons.
2.	Adam Gibson, Josh Patterson, Deep Learning, A Practitioner's Approach, Shroff Publisher /O'Reilly Publisher Media.
3.	Christopher M. Bishop, Neural Networks for Pattern Recognition, Oxford.
4.	Russell Reed, Robert J MarksII, Neural Smithing: Supervised Learning in Feedforward Artificial Neural Networks, Bradford Book Publishers.

Note: Though it's a theory course, there will be classes on computers for hands on practice. The activity content for the same is as follows.
• Introduction to Kaggle and how it can be used to enhance visibility. • Build general features to build a model for text analytics. • Build and deploy your own deep neural network on a website using tensor flow.

Year, Program, Semester	Multidisciplinary Minor II, 4th Semester onwards						
Course Code	MDM 2.4						
Course Category	Program Based Internship						
Course Title	**AI ML Related Internship**						
Teaching Scheme and Credits	**L**	**T**	**P**	**Total Contact Hours**	**Total Credits**		
	One Month				03		
Evaluation Scheme	**ISE**	**ESE**	**IOE**	**IPE**	**EOE**	**EPE**	**Total**
	00	00	50	-	50	-	100
Pre-requisites(if any)	Basics of unit processes and unit operations.						
Course Rationale	The course caters specifically to B.Tech Chemical Engineering students as the part of multidisciplinary Minor with respect to AI & ML applications in Chemical and allied Engineering. This course offers practical exposure to industry settings aligned with their chosen discipline, aiming to bridge the gap between theoretical knowledge and practical application. By engaging in a one-month internship, students gain firsthand experience, essential skills, and insights crucial for their future careers in additional sector of industry.						
Course Objectives	The course teacher will 1. Help expose students to the 'real' working environment. 2. Promote hands-on experience to the students' in their related field. 3. Develop synergetic collaboration between industry and the university in promoting a knowledgeable society. 4. Assist in providing the opportunity for students to test their interest in a particular career before permanent commitments are made. 5. Elaborate the dynamic and challenging nature of industrial environments.						
Course Outcomes	Upon completion of this course, student should be able to 1. Understand industrial processes and operations related to their minor sub-specializations. 2. Apply theoretical concepts to solve practical problems in the industry. 3. Communicate effectively with industry professionals, colleagues, and supervisors. 4. Collaborate efficiently in team environments to complete tasks and projects. 5. Adapt to the dynamic and challenging nature of industrial environments. 6. Reflect on internship experiences for personal and professional growth.						

Course Outcome and Program Outcome Mapping

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	-	-	-	-	-	-	-	-	-	-	-
CO 2	-	3	2	-	-	-	-	-	-	-	-	-
CO 3	-	-	-	-	-	-	-	-	-	3	-	-

CO 4	-	-	-	-	-	-	-	-	3	-	-	-
CO 5	-	-	-	-	-	2	-	-	-	-	-	3
CO 6	-	-	-	-	-	-	-	-	-	-	-	2

Level of Mapping as: Low 1, Moderate 2, High 3

Course Content	Hours
The course consists of a one-month internship with respect to applications of AI & ML. Students will be placed in companies or organizations that align with the particular requirement. During the internship, students will engage in various activities, including but not limited to: 1. Shadowing industry professionals to observe and learn about different processes and operations. 2. Assisting with ongoing projects or research initiatives within the organization. 3. Participating in hands-on tasks related to their minor sub-specialization, under the guidance of experienced mentors. 4. Attending training sessions, workshops, and seminars conducted by the industry to enhance their knowledge and skills. 5. Engaging in discussions and meetings with supervisors and colleagues to gain insights into industry practices, challenges, and innovations. 6. Documenting their internship experience through reports, presentations, or reflective journals. The period of one month for this internship will be during the winter or summer vacations, any such slots 4th Semester onwards.	4 weeks

Course Evaluation Method

This particular evaluation will be the part of the structure of 7th Semester.

The evaluation for the Industrial Internship course will be conducted as follows:

- **Internal Evaluation (50 marks):**
  - Assessment by course teachers based on students' performance during the internship, including attendance, participation, attitude, and contribution to assigned tasks.
  - Evaluation by industrial supervisors on students' professional conduct, technical skills, problem-solving abilities, and overall performance in the workplace.
- **External Evaluation (50 marks):**
  - Evaluation by an external examiner appointed by the institute, who will assess students' internship reports, presentations, or any other documentation submitted at the end of the internship period.
  - The external examiner will review the quality of students' reflections on their internship experience, their ability to apply theoretical knowledge to practical situations, and the depth of their understanding of industry practices and challenges.

The final grades for the Industrial Internship course will be determined based on the combined assessment from both internal and external evaluations.

Year, Program, Semester	Multidisciplinary Minor II, 4th Semester onwards						
Course Code	MDM 2.5						
Course Category	Project Based Learning						
Course Title	**Mini Project**						
Teaching Scheme and Credits	**L**	**T**	**P**	**Total Contact Hours**		**Total Credits**	
	-	-	-	-		02	
Evaluation Scheme	**ISE**	**ESE**	**IOE**	**IPE**	**EOE**	**EPE**	**Total**
	00	00	50	-	50	-	100
Pre-requisites(if any)	Basics of unit processes and unit operations.						
Course Rationale	This course aims to provide students with practical exposure and hands-on experience in real-world industrial settings, fostering a deeper understanding of theoretical concepts through application. By engaging in this field project, students will develop essential skills such as problem-solving, teamwork, and communication, preparing them for future challenges in the professional arena for AI ML applications.						
Course Objectives	The course teacher will 1. Facilitate application of theoretical knowledge. 2. Guide the students about enhancement of practical skills. 3. Explain about development of industry-relevant competencies.						
Course Outcomes	Upon completion of this course, student should be able to 1. Demonstrate application of theoretical concepts with instructor guidance. 2. Collaborate effectively in instructor-led team-based projects. 3. Communicate findings and insights professionally under instructor supervision.						

Course Outcome and Program Outcome Mapping

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	2	-	-	2	-	-	-	2	-	-	-
CO 2	-	-	3	-	-	-	-	-	3	-	2	1
CO 3	-	-	-	-	-	-	-	-	-	3	-	2

Level of Mapping as: Low 1, Moderate 2, High 3

Course Content

Minor Program Based Mini Project is a dynamic course designed to bridge the gap between classroom learning and real-world application. All the students will engage themselves in a series of tasks and challenge that will enable them to apply theoretical concepts learned in previous courses to solve practical problems. The project work need to be carried out independently covering a range of topics relevant to their field of study, allowing them to explore different facets of the particular discipline and develop versatile skill sets with respect to application of AI & ML.

This activity may be planned after 4th Semester and can be completed prior to 8th Semester of their Major studies.

Course Assessment Process
This particular evaluation will be the part of 8th Semester of the major structure. The course evaluation for the internals will be at the course teacher end while there will also be the external evaluation of the Project work. The teachers will follow the instructions as below: Evaluation Format: The evaluation may be conducted using a combination of assessment methods, including: • Rubric-based assessment for the project work and its report. • Peer evaluation for project. • Instructor-led discussions or presentations to evaluate communication skills and critical thinking. • Overall course grading based on a weighted average of individual assessments and participation. The evaluation format should be transparent, fair, and aligned with the course objectives and outcomes. Regular feedback and communication with students will ensure that the evaluation process remains supportive of their learning journey.

Multidisciplinary Minor
In
Piping Design Engineering

For
B.Tech (Chemical Engineering)

Shivaji University, Kolhapur
Department of Technology

Multidisciplinary Minor in Piping Design and Engineering

Teaching & Evaluation Scheme

Sr. No.	Category	Course Code	Course Title	Hours per week			Contact Hours	Credits	Evaluation Scheme	
									Theory	Practical
				L	T	P			ISE:ESE	IE:EE
1.	Preferably on SWAYAM (NPTEL) or any other MOOCs (Minor Program Core) Or In a Face-to-Face mode	MDM 3.1	Introduction to Piping Systems	03	-	-	03	03	30:70	00:00
2.		MDM 3.2	Piping Design Principles	03	-	-	03	03	30:70	00:00
3.		MDM 3.3	Piping Stress Analysis	03	-	-	03	03	30:70	00:00
4.	Program Based Internship	MDM 3.4	Piping Design Related Internship	One Month			-	03	-	50:50
5.	Project Based Learning	MDM 3.5	Mini Project	-	-	-	-	02	-	50:50
				-	-	-	-	14	300	200
			Total Hours	09	00	00	09	-	-	-

Note: MDM Program's Internship and Mini Project need to be planned during winter or summer vacation days after 4th semester while respective evaluations will be the part of 7th and 8th Semesters of the B.Tech Major structure.

Multidisciplinary Minor III: Piping Design Engineering

Year, Program, Semester	Multidisciplinary Minor III, 4th Semester onwards							
Course Code	MDM 3.1							
Course Category	Minor Program Core							
Course title	**Introduction to Piping Systems**							
Teaching Scheme and Credits	L	T	P	Total Contact Hours		Total Credits		
	03	-	-	03		03		
Evaluation Scheme	ISE	ESE		IOE	IPE	EOE	EPE	Total
	30	70		-	-	-	-	100
Pre-requisites(if any)	Basics of unit processes and unit operations							
Course Rationale	This course provides fundamental knowledge about piping systems, their components, and their role in chemical engineering processes.							
Course Objectives	The Course Teacher will 1. Describe different types of piping systems. 2. Explain the functions of valves, fittings, and other components in a piping system. 3. Elaborate the significance of proper piping design in chemical engineering processes.							
Course Outcomes	Upon completion of this course, student will be able to 1. Identify different types of piping systems. 2. Characterize the functions of various components in a piping system. 3. Analyze the importance of piping design in chemical engineering processes.							

Course Outcome and Program Outcome Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO 12
CO 1	2	-	-	-	-	-	-	-	-	-	-	-
CO 2	-	2	-	-	-	-	-	-	-	-	-	-
CO 3	-	-	3	-	-	-	-	-	-	-	-	-

Level of Mapping as: Low 1, Moderate 2, High 3

Unit No.	Course Content	Hours
I	**Introduction to Piping Systems** Types of piping systems: Classification based on application (e.g., process piping, utility piping, distribution piping), materials (e.g., metallic, non-metallic), and configuration (e.g., straight, branch, looped). Importance of piping systems in chemical engineering: Overview of the role of piping in transporting fluids, gases, and other substances within industrial processes.	**06**

II	**Piping Components** Valves and their functions: Types of valves (e.g., gate, globe, ball, butterfly) and their applications in controlling flow, pressure, and direction within piping systems. Fittings and their applications: Types of fittings (e.g., elbows, tees, reducers) and their roles in connecting and directing piping components.	**07**
III	**Piping Materials** Common materials used in piping: Overview of metallic (e.g., carbon steel, stainless steel, copper) and non-metallic (e.g., PVC, HDPE) materials used in piping construction, highlighting their properties and suitability for different applications. Material selection criteria: Factors influencing material selection, including mechanical properties, corrosion resistance, temperature and pressure requirements, and cost considerations.	**07**
IV	**Piping Design Fundamentals** Flow characteristics in piping systems: Principles of fluid flow (e.g., laminar, turbulent) and their implications for piping design, including flow rate calculations and pressure drop estimation. Pressure drop calculations: Methods for calculating pressure losses due to friction, elevation changes, and fittings in piping systems, and their significance in design optimization.	**06**
V	**Codes and Standards** Overview of industry standards for piping design: Introduction to relevant codes and standards (e.g., ASME B31.3, API 570) governing the design, fabrication, inspection, and maintenance of piping systems. Compliance requirements: Understanding the importance of compliance with regulatory standards and specifications in ensuring the safety, reliability, and legality of piping installations.	**06**
VI	**Piping Layout and Sizing** Layout considerations: Principles of piping layout, including factors such as accessibility, space constraints, process requirements, and safety regulations. Sizing calculations for pipes and components: Methods for determining the appropriate pipe diameter, wall thickness, and component sizing based on flow rates, pressure ratings, and fluid properties.	**07**

Reference Books	
1.	Mohinder L. Nayyar. (2018). Piping Handbook, Seventh Edition. McGraw-Hill Education.
2.	Roger Hunt. (2005). Piping: The Complete Guide to ASME B31.3. Gulf Professional Publishing.

Year, Program, Semester	Multidisciplinary Minor III, 4th Semester onwards							
Course Code	MDM 3.2							
Course Category	Minor Program Core							
Course title	**Piping Design Principles**							
Teaching Scheme and Credits	L	T	P	Total Contact Hours		Total Credits		
	03	-		03		03		
Evaluation Scheme	ISE		ESE	IOE	IPE	EOE	EPE	Total
	30		70	-	-	-	-	100
Pre-requisites(if any)	Basics of unit processes and unit operations							
Course Rationale	This course focuses on the principles and methodologies involved in the design of piping systems for chemical engineering applications.							
Course Objectives	The Course Teacher will 1. Describe design principles to create piping layouts. 2. Explain different design methodologies for piping systems. 3. Elaborate factors influencing piping design decisions.							
Course Outcomes	Upon completion of this course, student should be able to 1. Develop piping layouts for chemical engineering processes. 2. Compare and contrast various design methodologies for piping systems. 3. Justify design decisions based on factors such as safety, cost, and efficiency.							

Course Outcome and Program Outcome Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO 12
CO 1	-	-	3	-	-	-	-	-	-	-	-	-
CO 2	-	-	-	2	-	-	-	-	-	-	-	-
CO 3	-	-	-	-	2	-	-	-	-	-	-	-

Level of Mapping as: Low 1, Moderate 2, High 3

Unit No.	**Course Content**	**Hours**
I	**Piping Design Process** Steps involved in piping design: Overview of the design process, including conceptualization, preliminary design, detailed design, and as-built documentation. Design considerations: Factors influencing piping design decisions, such as process requirements, material selection, operating conditions, and regulatory compliance.	**06**
II	**Piping Codes and Standards** Overview of relevant codes and standards: Detailed examination of key industry standards and specifications governing piping design, fabrication, installation, and maintenance.	**09**

	Interpretation and application: Understanding how to interpret and apply code requirements to ensure compliance and best practices in piping design.	
III	**Design Methodologies** Traditional vs. computer-aided design approaches: Comparison of manual drafting methods with modern computer-aided design (CAD) software tools for piping layout and modeling. Design optimization techniques: Strategies for optimizing piping layouts and configurations to minimize material usage, pressure drop, and construction costs while maximizing efficiency and operability.	**07**
IV	**Safety in Piping Design** Hazard analysis and risk assessment: Techniques for identifying and mitigating potential hazards associated with piping systems, including hazard and operability (HAZOP) studies, risk matrices, and safety instrumented systems (SIS). Safety considerations in design decisions: Integration of safety factors and design features (e.g., relief devices, pressure relief valves) to prevent overpressure, leakage, and other hazardous conditions.	**06**
V	**Cost Estimation** Factors influencing piping design costs: Analysis of cost drivers in piping design, including material costs, labor expenses, equipment requirements, and project duration. Cost estimation methods: Techniques for estimating piping design costs at different stages of the project lifecycle, including conceptual, preliminary, and detailed design phases.	**06**
VI	**Environmental Considerations** Impact assessment of piping systems: Evaluation of the environmental impact of piping systems throughout their lifecycle, including energy consumption, greenhouse gas emissions, and waste generation. Sustainable design practices: Strategies for incorporating sustainability principles into piping design, such as minimizing resource usage, optimizing energy efficiency, and reducing environmental footprint.	**05**

Reference Books	
1.	Peter Smith and R.W. Zappe. (2018). Piping Systems Manual. McGraw-Hill Education.
2.	William Beale and Rodney Boyer. (2018). Process Piping: The Complete Guide to ASME B31.3, Fourth Edition. Momentum Press.

Year, Program, Semester	Multidisciplinary Minor III, 4th Semester onwards						
Course Code	MDM 3.3						
Course Category	Minor Program Core						
Course title	**Piping Stress Analysis**						
Teaching Scheme and Credits	L	T	P	Total Contact Hours	Total Credits		
	03	-	-	03	03		
Evaluation Scheme	ISE	ESE	IOE	IPE	EOE	EPE	Total
	30	70	-	-	-	-	100
Pre-requisites(if any)	Basics of unit processes and unit operations						
Course Rationale	This course provides an understanding of the principles and techniques used in analyzing the stress and stability of piping systems.						
Course Objectives	The course teacher will 1. Elaborate engineering principles to analyze stresses in piping systems. 2. Describe the stability of piping systems under various operating conditions. 3. Explain stress analysis results to make design modifications.						
Course Outcomes	The students will be able to 1. Perform stress analysis on piping systems. 2. Assess the stability of piping systems under different loading conditions. 3. Apply design modifications based on stress analysis results.						

Course Outcome and Program Outcome Mapping

CO/PO	PO 1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO 12
CO 1	-	-	3	-	-	-	-	-	-	-	-	-
CO 2	-	-	-	2	-	-	-	-	-	-	-	-
CO 3	-	-	-	-	2	-	-	-	-	-	-	-

Level of Mapping as: Low 1, Moderate 2, High 3

Unit No.	Course Content	Hours
I	**Introduction to Piping Stress Analysis** Types of stresses in piping systems: Overview of stress types including axial, bending, torsional, and thermal stresses. Importance of stress analysis: Understanding the necessity of stress analysis in ensuring the structural integrity and safety of piping systems.	06
II	**Fundamentals of Stress Analysis** Types of loads on piping systems: Examination of different types of loads including pressure, thermal, dead, live, and seismic loads. Stress calculation methods: Introduction to stress analysis methods such as finite element analysis (FEA), analytical methods, and empirical equations	07

III	**Piping Support Systems** Types of supports and their functions: Overview of support types including hangers, springs, guides, and anchors, and their roles in maintaining piping system stability. Design considerations for supports: Factors influencing support design such as load distribution, thermal expansion, and seismic restraint.	06
IV	**Thermal Stress Analysis** Effects of temperature changes on piping: Understanding thermal expansion and contraction phenomena and their impact on piping system integrity. Thermal stress calculation methods: Techniques for calculating thermal stresses including thermal expansion coefficients, stress intensification factors, and thermal gradients	06
V	**Dynamic Analysis** Vibration analysis of piping systems: Introduction to vibration modes, resonance, natural frequencies, and damping mechanisms in piping systems. Mitigation techniques: Strategies for mitigating piping vibrations including damping materials, supports, and structural modifications.	06
VI	**Case Studies and Applications** Real-world examples of piping stress analysis: Examination of case studies involving piping failures, stress concentration points, and successful stress analysis applications. Application of analysis results in design improvements: Understanding how stress analysis results inform design modifications to enhance piping system safety and reliability. Introduction to Piping material selection and construction.	08

Reference Books

1.	Metra, Peter. (2008). Piping Stress Analysis Design Guide. Elsevier.
2.	Alireza Bahadori. (2014). Piping and Pipeline Engineering: Design, Construction, Maintenance, Integrity, and Repair. Gulf Professional Publishing.

Year, Program, Semester	Multidisciplinary Minor III, 4th Semester onwards						
Course Code	MDM 3.4						
Course Category	Minor Program Based Internship						
Course title	**Piping Design Related Internship**						
Teaching Scheme and Credits	**L**	**T**	**P**	**Total Contact Hours**	**Total Credits**		
	One Month				03		
Evaluation Scheme	**ISE**	**ESE**	**IOE**	**IPE**	**EOE**	**EPE**	**Total**
	00	00	50	-	50	-	100
Pre-requisites(if any)	Basics of unit processes and unit operations.						
Course Rationale	The course caters special need of B.Tech Chemical Engineering students to upgrade themselves with respect to piping design engineering aspects. The course offers practical exposure to industry settings aligned with their chosen area of interest, aiming to bridge the gap between theoretical knowledge and practical application. By engaging in a one-month internship, students gain firsthand experience, essential skills, and insights crucial for their future careers in piping design engineering.						
Course Objectives	The course teacher will 1. Help expose students to the 'real' working environment. 2. Promote hands-on experience to the students' in their related field. 3. Develop synergetic collaboration between industry and the university in promoting a knowledgeable society. 4. Elaborate the dynamic and challenging nature of industrial environments.						
Course Outcomes	Upon completion of this course, student should be able to 1. Understand industrial processes and operations related to piping design. 2. Apply theoretical concepts to solve practical problems in the industry. 3. Communicate effectively with industry professionals, colleagues, and supervisors. 4. Collaborate efficiently in team environments to complete tasks and projects. 5. Adapt to the dynamic and challenging nature of industrial environments. 6. Reflect on internship experiences for personal and professional growth.						

Course Outcome and Program Outcome Mapping

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	-	-	-	-	-	-	-	-	-	-	-
CO 2	-	3	2	-	-	-	-	-	-	-	-	-
CO 3	-	-	-	-	-	-	-	-	-	3	-	-
CO 4	-	-	-	-	-	-	-	-	3	-	-	-
CO 5	-	-	-	-	-	2	-	-	-	-	-	3
CO 6	-	-	-	-	-	-	-	-	-	-	-	2

Level of Mapping as: Low 1, Moderate 2, High 3

Course Content	Hours
The course consists of a one-month internship in a relevant sector to undergo tasks with respect to piping design. Students will be placed in companies or organizations that align with their chosen MDM within the field of chemical engineering. During the internship, students will engage in various activities, including but not limited to: 1. Shadowing industry professionals to observe and learn about different processes and operations. 2. Assisting with ongoing projects or research initiatives within the organization. 3. Participating in hands-on tasks related to their minor sub-specialization, under the guidance of experienced mentors. 4. Attending training sessions, workshops, and seminars conducted by the industry to enhance their knowledge and skills. 5. Engaging in discussions and meetings with supervisors and colleagues to gain insights into industry practices, challenges, and innovations. 6. Documenting their internship experience through reports, presentations, or reflective journals. The period of one month for this internship will be during the winter or summer vacations, any such slots 4th Semester onwards.	4 weeks

Course Evaluation Method

This particular evaluation will be the part of the structure of 7th Semester.

The evaluation for the Industrial Internship course will be conducted as follows:

Internal Evaluation (50 marks):

Assessment by course teachers based on students' performance during the internship, including attendance, participation, attitude, and contribution to assigned tasks.

Evaluation by industrial supervisors on students' professional conduct, technical skills, problem-solving abilities, and overall performance in the workplace.

External Evaluation (50 marks):

Evaluation by an external examiner appointed by the institute, who will assess students' internship reports, presentations, or any other documentation submitted at the end of the internship period.

The external examiner will review the quality of students' reflections on their internship experience, their ability to apply theoretical knowledge to practical situations, and the depth of their understanding of industry practices and challenges.

The final grades for the Industrial Internship course will be determined based on the combined assessment from both internal and external evaluations.

Reference Books

1.	Alireza Bahadori. (2014). Piping and Pipeline Engineering: Design, Construction, Maintenance, Integrity, and Repair. Gulf Professional Publishing
2.	Mohinder L. Nayyar. (2018). Piping Handbook, Seventh Edition. McGraw-Hill Education.

Year, Program, Semester	Multidisciplinary Minor III, 4th Semester onwards						
Course Code	MDM 3.5						
Course Category	Project Based Learning						
Course Title	**Mini Project**						
Teaching Scheme and Credits	**L**	**T**	**P**	**Total Contact Hours**		**Total Credits**	
	-	-	-	-		02	
Evaluation Scheme	**ISE**	**ESE**	**IOE**	**IPE**	**EOE**	**EPE**	**Total**
	00	00	50	-	50	-	100
Pre-requisites(if any)	Basics of unit processes and unit operations.						
Course Rationale	This course aims to provide students with practical exposure and hands-on experience in real-world industrial settings, fostering a deeper understanding of theoretical concepts through application. By engaging in this field project, students will develop essential skills such as problem-solving, teamwork, and communication, preparing them for future challenges in the professional arena for piping design engineering.						
Course Objectives	The course teacher will 1. Facilitate application of theoretical knowledge. 2. Guide the students about enhancement of practical skills. 3. Explain about development of industry-relevant competencies.						
Course Outcomes	Upon completion of this course, student should be able to 1. Demonstrate application of theoretical concepts with instructor guidance. 2. Collaborate effectively in instructor-led team-based projects. 3. Communicate findings and insights professionally under instructor supervision.						

Course Outcome and Program Outcome Mapping

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	2	-	-	2	-	-	-	2	-	-	-
CO 2	-	-	3	-	-	-	-	-	3	-	2	1
CO 3	-	-	-	-	-	-	-	-	-	3	-	2

Level of Mapping as: Low 1, Moderate 2, High 3

Course Content

Minor Program Based Mini Project is a dynamic course designed to bridge the gap between classroom learning and real-world application. All the students will engage themselves in a series of tasks and challenge that will enable them to apply theoretical concepts learned in previous courses to solve practical problems. The project work need to be carried out independently covering a range of topics relevant to their field of study, allowing them to explore different facets of the particular discipline and develop versatile skill sets with respect to application of piping design basics.

This activity may be planned after 4th Semester and can be completed prior to 8th Semester of their Major studies.

Course Assessment Process
This particular evaluation will be the part of 8th Semester of the major structure. The course evaluation for the internals will be at the course teacher end while there will also be the external evaluation of the Project work. The teachers will follow the instructions as below: Evaluation Format: The evaluation may be conducted using a combination of assessment methods, including: • Rubric-based assessment for the project work and its report. • Peer evaluation for project. • Instructor-led discussions or presentations to evaluate communication skills and critical thinking. • Overall course grading based on a weighted average of individual assessments and participation. The evaluation format should be transparent, fair, and aligned with the course objectives and outcomes. Regular feedback and communication with students will ensure that the evaluation process remains supportive of their learning journey.

Shivaji University, Kolhapur
Department of Technology

B. Tech (Chemical Engineering), Exit after Second Year (Diploma in Chemical Engineering)

Teaching & Evaluation Scheme

Sr. No.	Category	Course Code	Course Title	Hours per week			Contact Hours	Credits	Evaluation Scheme	
									Theory	Practical
				L	T	P			ISE:ESE	IE:EE
1.	SWAYAM (NPTEL) Or Any other MOOCs Or Face to face mode Or Self-Study Mode (Program Core Courses)	DC- CHE 1	Introduction to Analytical Methods and Instrumentation	02	-	-	02	02	30:70	00:00
2.		DC- CHE 2	Introduction to Software Tools in Chemical Industry	02	-	-	02	02	30:70	00:00
3.		DC- CHE 3	Basics of Mass and Energy Balance	02	-	-	02	02	30:70	00:00
4.	Program Based Internship	DC-PBI	In plant Training	One Month				04	00:00	50:50
				-	-	-	-	**10***	**300****	**100**
			Total Hours	**06**	-	-	**06**	-	-	-

Note: The Workload against the Diploma Course will be finalised at the Program Level considering the strength of the students seeking for the Diploma.

*Obtaining these credits will be in addition to 85 regular credits up to SY B. Tech. Also in such cases, acquiring certificate after First Year is mandatory.

** There is an option for End Semester Examination either on respective MOOC platform if any or through the University System.

Note: Program Specific Industry Internship to be completed by such students before commencement of TY B. Tech.

<table>
<tr><td>Year, Program, Semester</td><td colspan="7">Exit after Second Year of B. Tech (Chemical Engineering), Diploma Claim</td></tr>
<tr><td>Course Code</td><td colspan="7">DC- CHE 1</td></tr>
<tr><td>Course Category</td><td colspan="7">Course for Diploma in Chemical Engineering</td></tr>
<tr><td>Course title</td><td colspan="7">Introduction to Analytical Methods and Instrumentation</td></tr>
<tr><td rowspan="2">Teaching Scheme and Credits</td><td>L</td><td>T</td><td>P</td><td colspan="2">Total Contact Hours</td><td colspan="2">Total Credits</td></tr>
<tr><td>02</td><td>-</td><td>-</td><td colspan="2">02</td><td colspan="2">02</td></tr>
<tr><td rowspan="2">Evaluation Scheme</td><td colspan="2">ISE</td><td>ESE</td><td>IOE</td><td>IPE</td><td>EOE</td><td>EPE</td><td>Total</td></tr>
<tr><td colspan="2">30</td><td>70</td><td>-</td><td>-</td><td>-</td><td>-</td><td>100</td></tr>
<tr><td>Pre-requisites(if any)</td><td colspan="7">Basic understanding of chemistry concepts, including stoichiometry, chemical equations, and chemical reactions. Familiarity with scientific measurements and laboratory techniques is recommended.</td></tr>
<tr><td>Course Rationale</td><td colspan="7">The course imparts fundamental knowledge and skills in analytical chemistry, covering various techniques, instruments, and methodologies for accurate sample analysis and data interpretation. It prepares students for reliable quantitative and qualitative analysis in research and industry.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">The course teacher will
1. To understand the principles and applications of analytical methods in various fields.
2. To develop proficiency in using analytical instruments and techniques for sample analysis.
3. To apply statistical analysis and data interpretation skills to ensure accurate and reliable results.
4. To gain practical knowledge in method development, optimization, and validation for different analytical approaches.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">Upon completion of this course, student should be able to
1. Demonstrate proficiency in utilizing analytical instruments and techniques for sample analysis.
2. Apply critical thinking and problem-solving skills to interpret and evaluate analytical data accurately.
3. Employ appropriate statistical methods to analyze and interpret analytical results effectively.
4. Design and execute analytical experiments while adhering to quality control and assurance principles.</td></tr>
</table>

Course Outcome and Program Outcome Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO 12
CO 1	-	3	3	-	2	-	-	-	-	-	-	-
CO 2	-	3	2	2	-	-	-	-	-	-	-	-
CO 3	-	-	2	-	3	2	-	-	-	-	-	-
CO 4	-	2	2	-	2	-	-	-	-	-	-	-

Level of Mapping as: Low 1, Moderate 2, High 3

Unit No.	Course Content	Hours
I	**Introduction to Analytical Methods and Instrumentation** • Overview of analytical chemistry and its applications. • Sampling techniques and sample preparation methods. • Introduction to analytical instruments and their selection criteria. • Importance of calibration and quality assurance. • Basic statistical analysis in analytical chemistry.	**04**
II	**Spectroscopic Methods** • Principles of spectroscopy and its various techniques. • UV-Visible spectroscopy for quantitative analysis. • Infrared (IR) spectroscopy for functional group analysis. • Nuclear Magnetic Resonance (NMR) spectroscopy for structure determination. • Mass spectrometry for compound identification.	**04**
III	**Chromatographic Methods** • Principles of chromatographic separation. • Gas Chromatography (GC) and its applications. • High-Performance Liquid Chromatography (HPLC) and method development. • Thin-Layer Chromatography (TLC) for qualitative analysis.	**04**
IV	**Electrochemical Methods** • Basics of electrochemistry and its applications. • Potentiometry for pH measurement and ion analysis. • Voltammetry techniques for trace analysis. • Amperometry, Coulometry, and Faraday's laws.	**04**
V	**Separation Techniques**	**04**

	• Overview of separation techniques in analytical chemistry. • Liquid-Liquid Extraction and its applications. • Solid-Phase Extraction (SPE) for sample clean-up and concentration. • Ion Exchange Chromatography for separation and method development. • Gel Electrophoresis for DNA, RNA, and protein separation.	
VI	**Advanced Analytical Techniques** • Thermal analysis techniques: DSC and TGA. • Atomic Spectroscopy: AAS and ICP for elemental analysis. • X-ray Diffraction (XRD) for crystallography and phase identification. • Mass Spectrometry Imaging (MSI) for imaging applications. • Hyphenated Techniques: GC-MS and LC-MS.	**04**
Reference Books		
1.	Harris, D. C. (2015). Quantitative Chemical Analysis (9th ed.). W. H. Freeman and Company.	
2.	Merritt, W. H., et al. (2004). Instrumental Methods of Analysis (7th ed.). CBS.	
3.	Skoog, D. A., et al. (2014). Fundamentals of Analytical Chemistry (9th ed.). Brooks/Cole.	
4.	Rouessac, F., & Rouessac, A. (2022). Chemical Analysis: Modern Instrumentation Methods and Techniques (3rd ed.). Wiley.	
Useful web links		
1.	https://acsanalytical.org/	
2.	https://chemcollective.org/	

<table>
<tr><td>Year, Program, Semester</td><td colspan="7">Exit after Second Year of B. Tech (Chemical Engineering), Diploma Claim</td></tr>
<tr><td>Course Code</td><td colspan="7">DC- CHE 2</td></tr>
<tr><td>Course Category</td><td colspan="7">Course for Diploma in Chemical Engineering</td></tr>
<tr><td>Course title</td><td colspan="7">Introduction to Software Tools in Chemical Industry</td></tr>
<tr><td rowspan="2">Teaching Scheme and Credits</td><td>L</td><td>T</td><td>P</td><td colspan="2">Total Contact Hours</td><td colspan="2">Total Credits</td></tr>
<tr><td>02</td><td>-</td><td>-</td><td colspan="2">02</td><td colspan="2">02</td></tr>
<tr><td rowspan="2">Evaluation Scheme</td><td colspan="2">ISE</td><td>ESE</td><td>IOE</td><td>IPE</td><td>EOE</td><td>EPE</td><td>Total</td></tr>
<tr><td colspan="2">30</td><td>70</td><td>-</td><td>-</td><td>-</td><td>-</td><td>100</td></tr>
<tr><td>Pre-requisites(if any)</td><td colspan="7">The pre-requisite for this course is fundamental understanding of computer operation, a basic understanding of mathematics, including algebra, geometry, and basic calculus and Basic Programming Skills. Students should be comfortable with concepts such as moles, mass balances, and chemical processes and equations.</td></tr>
<tr><td>Course Rationale</td><td colspan="7">The course aims to provide students with a comprehensive understanding of software tools used in the chemical industry. The course is designed to equip students with the knowledge and practical experience necessary to effectively utilize software tools, improving efficiency, productivity, and safety in chemical engineering processes.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">The course teacher will
1. Familiarize students with essential software tools commonly used in the chemical industry.
2. Provide an understanding of the role of software tools in various processes within the chemical industry, including analysis, simulation, and optimization.
3. Equip students with practical skills to effectively utilize software tools for data analysis, visualization, and interpretation.
4. Introduce students to programming languages relevant to chemical engineering applications, such as Python or MATLAB.
5. Develop problem-solving abilities by applying software tools to solve real-world challenges encountered in the chemical industry.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">Upon completion of this course, student should be able to
1. Demonstrate proficiency in using software tools and Solve basic chemical engineering problems using MS-Excel and MATLAB
2. Apply software tools for process simulation and optimization to solve chemical engineering problems.
3. Develop basic programming skills in relevant languages for chemical engineering applications.</td></tr>
</table>

	4. Evaluate and select appropriate software tools based on specific project requirements and constraints. 5. Interpret and communicate analysis results effectively through graphical representations and technical reports.

Course Outcome and Program Outcome Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO 12
CO 1	2	-	-	-	-	-	-	-	-	-	-	-
CO 2	3	2	2	-	2	-	-	-	-	-	-	-
CO 3	2	2	2	1	2	-	-	-	-	-	-	-
CO 4	2	2	3	2	3	-	-	-	-	-	-	-
CO 5	2	2	1	1	3	-	-	-	-	-	-	-

Level of Mapping as: Low 1, Moderate 2, High 3

Unit No.	Course Content	Hours
I	**Introduction to Software Tools in the Chemical Industry** • Overview of software tools used in chemical engineering, • Importance of software tools in the chemical industry • Applications of software tools in the chemical industry	04
II	**Spreadsheet Applications in Chemical Engineering** • Basic functions and formulas in spreadsheet software (e.g., Microsoft Excel), • Application in Density, molecular weight, mole and percentage compositions, • Empirical and Molecular formula calculations, Heat of mixing, Gas laws, Vapour pressure, Chemical Kinetics calculations, • Engineering calculations and problem-solving using spreadsheets	04
III	**Introduction to Programming for Chemical Engineers** • Basics of programming concepts (variables, loops, conditionals), • Introduction to a programming language (e.g., Python), • Writing scripts for automation and data analysis	04
IV	**Process Simulation Software** • Introduction to process simulation software (Aspen, HYSYS, ChemCAD), • Building and simulating process flowsheets • Performing material and energy balances • Introduction to process optimization	08

	• Use of open-source software in Chemical Engineering (DWSIM, ASALI, Reactor Lab, SciLab) for solving chemical engineering problems. Tools for hydraulic design, calculation of differential head of pumps, sizing of pipelines, P&ID development tools (Smart Plant PIDs (SPPID)	
V	**Chemical Engineering Drawing Software** • Overview of drawing software (e.g., AutoCAD, SolidWorks) • Creating and editing engineering drawings, Annotations, dimensions, • Detailing in engineering drawings	**04**
Reference Books		
1.	Michael E. Hanyak Jr. (2019). Chemical Process Simulation and the Aspen HYSYS Software. CRC Press.	
2.	Mariano Martín Martín, (July 2014), Introduction to Software for Chemical Engineers, 1st edition, CRC Press.	
3.	William J. Palm III. (2014). Introduction to MATLAB for Engineers. McGraw-Hill Education.	
4.	Dominic C.Y. Foo, (2022), Chemical Engineering Process Simulation, Second Edition, Elsevier Inc.	
Useful web links		
1.	https://www.mathworks.com/products/matlab.html	
2.	www.chemstations.com	

<table>
<tr><td>Year, Program, Semester</td><td colspan="8">Exit after Second Year of B. Tech (Chemical Engineering), Diploma Claim</td></tr>
<tr><td>Course Code</td><td colspan="8">DC- CHE 3</td></tr>
<tr><td>Course Category</td><td colspan="8">Course for Diploma in Chemical Engineering</td></tr>
<tr><td>Course title</td><td colspan="8">Basics of Mass and Energy Balance</td></tr>
<tr><td rowspan="2">Teaching Scheme and Credits</td><td>L</td><td>T</td><td>P</td><td colspan="3">Total Contact Hours</td><td colspan="2">Total Credits</td></tr>
<tr><td>02</td><td>-</td><td>-</td><td colspan="3">02</td><td colspan="2">02</td></tr>
<tr><td rowspan="2">Evaluation Scheme</td><td colspan="2">ISE</td><td>ESE</td><td>IOE</td><td>IPE</td><td>EOE</td><td>EPE</td><td>Total</td></tr>
<tr><td colspan="2">30</td><td>70</td><td>-</td><td>-</td><td>-</td><td>-</td><td>100</td></tr>
<tr><td>Pre-requisites(if any)</td><td colspan="8">Prerequisites include proficiency in calculus, chemistry knowledge (stoichiometry and chemical reactions), familiarity with physics concepts (energy, heat transfer, thermodynamics), and basic engineering fundamentals (material properties, fluid mechanics).</td></tr>
<tr><td>Course Rationale</td><td colspan="8">This course is crucial for chemical engineering students as it imparts the fundamental knowledge needed to understand the principles of mass and energy conservation in engineering systems. Through this course, students develop the skills to analyze and optimize processes, ensuring efficient utilization of materials and energy. This knowledge forms the foundation for designing and operating systems that align with sustainability goals and resource conservation.</td></tr>
<tr><td>Course Objectives</td><td colspan="8">The course teacher will
1. Explain the fundamental concepts and principles of mass and energy balance.
2. Perform accurate mass balance calculations for steady-state and transient systems.
3. Apply energy balance equations to analyze and quantify energy transfers and conversions.
4. Demonstrate the ability to integrate mass and energy balance calculations to solve real-world engineering problems.</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">Upon completion of this course, student should be able to
1. Demonstrate a thorough understanding of mass balance principles and their application in engineering systems.
2. Perform accurate and comprehensive energy balance calculations to analyze energy transfers and conversions.
3. Apply combined mass and energy balance concepts to solve complex engineering problems and optimize system performance.
4. Utilize software tools and simulations effectively to model and evaluate mass and energy balance in practical applications.</td></tr>
</table>

Course Outcome and Program Outcome Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO 12
CO 1	3	-	-	2	-	-	-	-	-	-	-	-
CO 2	2	2	-	-	3	-	-	-	-	-	-	-
CO 3	-	-	-	2	2	-	2	-	-	-	-	-
CO 4	-	-	2	-	2	2	-	-	-	-	-	-

Level of Mapping as: Low 1, Moderate 2, High 3

Unit No.	Course Content	Hours
I	**Introduction to Mass and Energy Balance** • Overview of mass and energy balance principles • Conservation laws and their application • Units and dimensions in mass and energy balance • Introduction to system boundaries and control volumes	06
II	**Mass Balance** • Material properties and flow rates • Mass balance equations and calculations • Steady-state and transient mass balance • Application of mass balance to various systems (e.g., chemical processes, environmental systems)	04
III	**Energy Balance** • Forms of energy and energy transfer mechanisms • Energy balance equations and calculations • Steady-state and transient energy balance • Heat transfer, work, and energy conversion	04
IV	**Combined Mass and Energy Balance** • Simultaneous mass and energy balance calculations • Enthalpy and specific heat calculations • Heat and mass transfer in systems • Applications of combined balance in process engineering	04
V	**Advanced Topics in Mass and Energy Balance** • Multiple systems and interconnected processes • Chemical reactions and reaction heat • Energy storage and heat exchange	04

	• Non-ideal systems and phase changes	
VI	**Practical Applications and Case Studies** • Industrial applications of mass and energy balance • Case studies involving complex systems • Optimization and problem-solving techniques • Introduction to process simulation software	**04**
Reference Books		
1.	Smith, J. M., Van Ness, H. C., Abbott, M. M., & Swihart, G. H. (2018). Introduction to Chemical Engineering Thermodynamics. McGraw-Hill Education.	
2.	Felder, R. M., & Rousseau, R. W. (2016). Elementary Principles of Chemical Processes. Wiley.	
3.	Bird, R. B., Stewart, W. E., & Lightfoot, E. N. (2007). Transport Phenomena. John Wiley & Sons.	
4.	Seader, J. D., & Henley, E. J. (2010). Separation Process Principles. John Wiley & Sons.	
Useful web links		
1.	https://learncheme.com/	
2.	www.cheresources.com	

<table>
<tr><td>Year, Program, Semester</td><td colspan="7">Exit after Second Year of B. Tech (Chemical Engineering), Diploma Claim</td></tr>
<tr><td>Course Code</td><td colspan="7">DC-PBI</td></tr>
<tr><td>Course Category</td><td colspan="7">Course for Diploma in Chemical Engineering</td></tr>
<tr><td>Course title</td><td colspan="7">In Plant Training</td></tr>
<tr><td rowspan="2">Teaching Scheme and Credits</td><td>L</td><td>T</td><td>P</td><td colspan="3">Total Contact Hours</td><td>Total Credits</td></tr>
<tr><td colspan="5">One Month</td><td>04</td></tr>
<tr><td rowspan="2">Evaluation Scheme</td><td colspan="2">ISE</td><td>ESE</td><td>IOE</td><td>IPE</td><td>EOE</td><td>EPE</td><td>Total</td></tr>
<tr><td colspan="2">-</td><td>-</td><td>50</td><td>-</td><td>50</td><td>-</td><td>100</td></tr>
<tr><td>Pre-requisites(if any)</td><td colspan="7">Completion of all the courses of FY B. Tech Chemical Engineering Major, also the completion of all the courses to claim Certificate in Chemical Engineering.</td></tr>
<tr><td>Course Rationale</td><td colspan="7">The purpose of the In Plant Training course is to provide students with practical exposure to the chemical engineering industry. This hands-on experience allows students to apply theoretical knowledge gained in the classroom to real-world scenarios. By engaging in industrial training, students develop essential skills, gain industry insights, and enhance their employability in the chemical engineering field.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">The training will ensure students
1. To gain practical exposure to industrial processes in chemical engineering.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">Upon completion of the In-Plant Training course, students will be able to
1. Understand industrial processes in chemical engineering.
2. Apply theoretical knowledge to practical situations.
3. Utilize tools and techniques effectively in experiments.
4. Identify and mitigate workplace safety hazards.
5. Collaborate effectively in multidisciplinary teams.
6. Communicate findings professionally.</td></tr>
</table>

Course Outcome and Program Outcome Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO 12
CO 1	3	-	-	-	-	-	-	-	-	-	-	-
CO 2	-	3	-	-	-	-	-	-	-	-	-	-
CO 3	-	-	2	-	-	-	-	-	-	-	-	-
CO 4	-	-	-	2	-	-	-	-	-	-	-	-
CO 5	-	-	-	-	-	-	-	-	3	-	-	-

CO 6	-	-	-	-	-	-	-	-	-	3	-	-

Level of Mapping as: Low 1, Moderate 2, High 3

Course Content

The In-Plant Training course encompasses a comprehensive blend of theoretical learning and hands-on experience in an industrial setting. The course content includes:

1. Introduction to Chemical Engineering Industry: Overview of different sectors, processes, and applications within the chemical engineering domain.
2. Safety Procedures and Protocols: Training on safety regulations, hazard identification, emergency procedures, and personal protective equipment (PPE) usage.
3. Equipment Familiarization: Hands-on experience with common equipment and instrumentation used in chemical engineering processes, including pumps, reactors, distillation columns, and control systems.
4. Process Simulation and Optimization: Practical exercises on process simulation software and optimization techniques to enhance efficiency and productivity.
5. Troubleshooting and Maintenance: Practical sessions on diagnosing and resolving equipment malfunctions, conducting routine maintenance, and ensuring operational integrity.
6. Industrial Visits and Guest Lectures: Field trips to industrial facilities and guest lectures by industry experts to provide first hand insights into real-world applications and challenges.
7. Project Work: Collaborative projects or case studies addressing specific engineering problems or process improvements relevant to the host industry.
8. Evaluation and Assessment: Continuous evaluation based on performance during training, report submissions with the components of the report has been separately mentioned under Evaluation Method.

Evaluation Method

1. **Attendance and Participation:** Regular attendance and active participation in training sessions, workshops, and industrial visits will be monitored.
2. **Skills Assessment:** Evaluation of practical skills demonstrated during hands-on training activities, including equipment operation, experimentation, troubleshooting, and safety compliance.
3. **Performance Review:** Ongoing assessment of individual and group performance based on assigned tasks, projects, and team collaborations.
4. **Supervisor Feedback:** Feedback from industry supervisors regarding student performance, professionalism, attitude, and adaptability in the workplace.
5. **Training Report:** Submission of a comprehensive training report summarizing the learning outcomes, experiences, observations, and insights gained during the In Plant Training

period.

Training Report Format: The training report should follow a structured format to ensure clarity, coherence, and completeness. Here's a suggested outline:

1. Title Page:

- Title of the report: "In Plant Training Report"
- Student's name
- Enrolment number
- Department/Program
- Name of the institution
- Duration of the training period
- Name and address of the host industry

2. Acknowledgments (Optional):

- Acknowledge any individuals, organizations, or institutions that contributed to the training experience.

3. Table of Contents:

- List of sections and subsections with corresponding page numbers.

4. Introduction:

- Brief overview of the training objectives, scope, and significance.
- Description of the host industry and the specific department or division where the training was conducted.

5. Training Objectives:

- Recapitulation of the objectives outlined at the beginning of the training period.

6. Training Activities:

- Detailed account of the activities undertaken during the training, including:
  - Description of the tasks assigned and responsibilities undertaken.
  - Summary of workshops, seminars, industrial visits, and hands-on training sessions participated in.
  - Highlights of any notable experiences, challenges faced, and lessons learned.

7. Skills Acquired:

- Discussion of the practical skills and knowledge gained throughout the training period.
- Reflection on the application of theoretical concepts in real-world industrial scenarios.

8. Observations and Insights:

- Analysis of observations made during the training, including:
  - Observations regarding industry practices, processes, and technologies.
  - Insights into workplace dynamics, organizational culture, and professional etiquettes.
  - Suggestions for improvement or areas of further learning identified during the training.

9. Conclusion:

- Summary of key takeaways and learning outcomes from the training experience.

10. References:

- List of sources referenced or consulted during the preparation of the report (if applicable).

11. Appendices (Optional):

- Additional materials such as photographs, diagrams, charts, or supplementary documents supporting the content of the report.

12. Declaration:

- Statement affirming the authenticity and originality of the report, along with the student's signature and date.

The training report should be well-organized, concise, and professionally presented, demonstrating the student's ability to articulate their learning experiences and insights gained during the In-Plant Training period.

Reference Books	
1.	Shreve, R.N., & Brink Jr., J.A. (2017). Chemical Process Industries
2.	McCabe, W.L., Smith, J.C., & Harriott, P. (2018). Unit Operations of Chemical Engineering
3.	Perry, R.H., & Green, D.W. (Eds.). (2018). Perry's Chemical Engineers' Handbook
4.	Sinnott, R.K., & Coulson, G.F. (2012). Chemical Engineering Design
5.	Luyben, M.L. (2016). Process Control: A Practical Approach
6.	King, R. (2017). Safety in the Process Industries
Useful web links	
1.	www.internshala.com

Shivaji University
Vidyanagar, Kolhapur - 416 004, Maharashtra.

Department of Technology

As per NEP2020 guidelines

MDM Featured B. Tech (Chemical Engineering), Honors and Honors with Research, Detailed Curriculum.

Shivaji University, Kolhapur
Department of Technology

MDM Featured B. Tech (Chemical Engineering) with Honors

Teaching and Evaluation Scheme

Sr. No.	Category	Code	Course Title	Hours per week			Contact Hours	Credits	Evaluation Scheme	
									Theory	Practical
				L	T	P			ISE:ESE	IE:EE
1.	SWAYAM (NPTEL) or any other MOOCs Or Self-study mode with University's End Semester Examination (Program Core Courses)	HN- 1	Research Methodology	03	-	-	03	03	30:70	00:00
2.		HN- 2	Advanced Reaction Engineering	03	-	-	03	03	30:70	00:00
3.		HN- 3	Advanced Chemical Engineering Thermodynamics	03	-	-	03	03	30:70	00:00
4.		HN- 4	Process Optimization and Control	03	-	-	03	03	30:70	00:00
5.		HN- 5	Bioprocess Engineering	03	-	-	03	03	30:70	00:00
6.	Ability Enhancement Course	HN-AEC1	Advanced Laboratory Practice	-	-	04	04	02	-	50:50
				-	**-**	**-**	**-**	**17**	**500**	**100**
			Total Hours	**15**	**-**	**04**	**19**	**-**	**-**	**-**

<table>
<tr><td>Year, Program, Semester</td><td colspan="7">B. Tech Chemical Engineering (Honors/Honors with Research)</td></tr>
<tr><td>Course Code</td><td colspan="7">HN-1</td></tr>
<tr><td>Course Category</td><td colspan="7">Core</td></tr>
<tr><td>Course title</td><td colspan="7">Research Methodology</td></tr>
<tr><td rowspan="2">Teaching Scheme and Credits</td><td>L</td><td>T</td><td>P</td><td colspan="2">Total Contact Hours</td><td colspan="2">Total Credits</td></tr>
<tr><td>03</td><td>-</td><td>-</td><td colspan="2">03</td><td colspan="2">03</td></tr>
<tr><td rowspan="2">Evaluation Scheme</td><td colspan="2">ISE</td><td>ESE</td><td>IOE</td><td>IPE</td><td>EOE</td><td>EPE</td><td>Total</td></tr>
<tr><td colspan="2">30</td><td>70</td><td>-</td><td>-</td><td>-</td><td>-</td><td>100</td></tr>
<tr><td>Pre-requisites(if any)</td><td colspan="7">NA</td></tr>
<tr><td>Course Rationale</td><td colspan="7">The course is designed to equip students with the necessary knowledge and skills to conduct research effectively in engineering fields. The course will cover various aspects of research design, data collection, analysis, and reporting. Emphasis will be placed on understanding different research methodologies, ethical considerations, literature review techniques, and research proposal development.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">The Course Teacher will
1. Introduce diverse research methodologies and approaches in scientific inquiry.
2. Foster critical thinking and analytical skills essential for research.
3. Offer practical guidance in designing research studies, including formulating questions and hypotheses.
4. Develop skills in conducting literature reviews, data analysis, and interpreting findings.
5. Instill ethical research practices and integrity in the research process.
6. Prepare students for effective communication of research findings through presentations, reports, and scholarly publications.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">Upon completion of this course, student should be able to
1. Understand various research methodologies, encompassing quantitative, qualitative, and mixed methods approaches.
2. Assess existing research literature, pinpointing gaps, and formulate pertinent research questions and hypotheses.
3. Demonstrate proficiency in research design, encompassing the selection of appropriate methodologies, sampling techniques, and data collection methods.
4. Acquire practical skills in data analysis techniques, including statistical analysis, qualitative coding, and thematic analysis.
5. Uphold ethical guidelines and principles in research, encompassing</td></tr>
</table>

	obtaining informed consent, ensuring confidentiality, and preventing plagiarism. 6. Effectively communicate research findings through written reports, oral presentations, and academic publications.

Course Outcome and Program Outcome Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO 12
CO 1	3	-	3	2	-	1	-	3	-	3	-	-
CO 2	-	3	-	3	-	-	-	-	-	3	-	2
CO 3	-	3	3	2	-	-	2	-	1	-	3	-
CO 4	-	2	-	3	3	-	-	1	-	-	3	-
CO 5	-	-	-	-	3	-	-	3	-	-	-	-
CO 6	-	-	-	-	-	3	-	-	3	3	-	3

Level of Mapping as: Low 1, Moderate 2, High 3

Unit No.	Course Content	Hours
I	**Introduction to Research Methodology:** Understanding the Research Process, Importance of Research in Engineering, Types of Research: Basic vs. Applied, Quantitative vs. Qualitative, Research Paradigms: Positivism, Interpretivism, Pragmatism, Formulating Research Questions and Objectives, Literature Review: Search Strategies, Critical Analysis, Research Ethics and Integrity, Research Design: Experimental, Descriptive, Exploratory, Case Study.	07
II	**Research Design and Sampling Techniques:** Research Variables and Hypothesis Formulation, Experimental Design: Control Groups, Randomization, Replication, Survey Design: Questionnaire Construction, Scaling Techniques, Sampling Methods: Probability Sampling, Non-probability Sampling, Sample Size Determination and Power Analysis, Case Study Research Design, Qualitative Research Design: Interviews, Focus Groups, Observations, Mixed-Methods Research Design.	07
III	**Data Collection and Analysis: Data Collection Techniques:** Surveys, Interviews, Observations, Experiments, Instrumentation and Measurement Tools, Data Quality and Validation, Data Analysis Methods: Descriptive Statistics, Inferential Statistics, Statistical Software Tools: SPSS, R, MATLAB, Qualitative Data Analysis: Coding, Theme Analysis, Narrative Analysis.	06
IV	**Research Proposal Development:** Components of a Research Proposal: Title, Abstract, Introduction, Literature Review, Methodology, Timeline, Budget, Writing and Organizing a Research Proposal, Proposal Review Process and Feedback Incorporation, Presentation Skills for Research Proposals, Grant Writing Techniques and Funding Opportunities, Ethical Considerations in Research Proposal Development.	07

V	**Advanced Research Methods:** Longitudinal and Cross-Sectional Studies, Meta-Analysis and Systematic Reviews, Action Research and Participatory Research, Simulation and Modeling Techniques, Big Data Analytics in Engineering Research, Emerging Trends in Research Methodology.	**06**
VI	**Research Project Management and Publication:** Project Planning and Time Management, Collaboration and Teamwork in Research Projects, Data Management and Documentation, Intellectual Property Rights and Patents, Writing and Publishing Research Papers, Peer Review Process and Journal Selection.	**06**
Text Books		
1.	Creswell, J. W., & Creswell, J. D. (2017). Research Design: Qualitative, Quantitative, and Mixed Methods Approaches. SAGE Publications.	
2.	Bryman, A., & Bell, E. (2015). Business Research Methods, Oxford University Press.	
3.	Kumar, R. (2019). Research Methodology: A Step-by-Step Guide for Beginners, SAGE Publications.	
Reference Books		
1.	Neuman, W. L. (2013). Social Research Methods: Qualitative and Quantitative Approaches. Pearson.	
2.	Kothari, C. R. Garg, G. (2019). Research Methodology: Methods and Techniques, 5th Edition, New Age Int. Publisher.	
Useful web links		
1.	https://www.researchgate.net/topic/Research-Methodology	
2.	https://www.coursera.org/learn/research-methods	
3.	https://www.socialresearchmethods.net/kb	
4.	https://onlinecourses.nptel.ac.in/noc23_ge36/preview	

<table>
<tr><td>Year,Program, Semester</td><td colspan="7">B. Tech Chemical Engineering (Honors/Honors with Research)</td></tr>
<tr><td>Course Code</td><td colspan="7">HN-2</td></tr>
<tr><td>Course Category</td><td colspan="7">Core</td></tr>
<tr><td>Course title</td><td colspan="7">Advanced Reaction Engineering</td></tr>
<tr><td rowspan="2">Teaching Scheme and Credits</td><td>L</td><td>T</td><td>P</td><td colspan="2">Total Contact Hours</td><td colspan="2">Total Credits</td></tr>
<tr><td>03</td><td>-</td><td>-</td><td colspan="2">03</td><td colspan="2">03</td></tr>
<tr><td rowspan="2">Evaluation Scheme</td><td colspan="2">ISE</td><td>ESE</td><td>IOE</td><td>IPE</td><td>EOE</td><td>EPE</td><td>Total</td></tr>
<tr><td colspan="2">30</td><td>70</td><td>-</td><td>-</td><td>-</td><td>-</td><td>100</td></tr>
<tr><td>Pre-requisites(if any)</td><td colspan="7">PCC 312</td></tr>
<tr><td>Course Rationale</td><td colspan="7">Course aims to provide students with an in-depth understanding of advanced concepts, theories, and applications in chemical reaction engineering. The course will cover topics such as advanced reaction kinetics, reactor design for complex reactions, catalysis, multiphase reactions, and emerging trends in reaction engineering. Emphasis will be placed on critical analysis, advanced mathematical modeling, and applications in cutting-edge research and industrial settings.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">The Course Teacher will
1. Present advanced concepts in chemical kinetics, covering complex reaction mechanisms and kinetics modeling.
2. Discuss advanced principles of reactor design, addressing complex reactions and non-ideal reactor behavior.
3. Introduce principles and applications of catalysis in chemical reaction engineering.
4. Analyze multiphase reactions, emphasizing design and operation of multiphase reactors.
5. Explore advanced topics, including enzymatic reaction engineering, electrochemical reactions, and emerging trends in reaction engineering research.
6. Present sector-specific case studies and facilitate problem-solving sessions for complex engineering problems in reaction engineering.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">Upon completion of this course, student should be able to
1. Demonstrate mastery of complex reaction mechanisms and kinetic models, applying them to predict reaction rates in diverse chemical systems.
2. Design and analyze advanced reactors for complex reactions, considering non-ideal flow patterns, residence time distributions, and dynamic behavior.</td></tr>
</table>

	3. Evaluate catalytic processes and design optimal catalytic reactors, considering catalyst deactivation, diffusion limitations, and reaction selectivity. 4. Analyze and model multiphase reactions, designing reactors for gas-liquid, gas-solid, and liquid-solid systems. 5. Evaluate advanced topics in reaction engineering, including enzymatic reactions, electrochemical processes, and emerging trends, for research and industrial applications. 6. Explain sector-specific case studies and proficiently solve complex engineering problems in reaction engineering.

Course Outcome and Program Outcome Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO 12
CO 1	3	3	3	2	2	1	-	-	-	3	-	-
CO 2	3	3	3	2	2	1	-	-	2	3	-	-
CO 3	3	1	3	1	-	3	-	3	2	-	-	-
CO 4	3	3	3	3	-	-	3	1	-	-	-	-
CO 5	3	-	3	-	3	-	1	-	-	-	-	3
CO 6	-	3	-	3	-	-	-	3	3	-	3	-

Level of Mapping as: Low 1, Moderate 2, High 3

Unit No.	Course Content	Hours
I	**Advanced Reaction Kinetics:** Complex Reaction Mechanisms and Kinetic Models, Transition State Theory and Molecular Dynamics, Quantum Chemical Methods in Reaction Kinetics, Non-Elementary Reaction Kinetics, Chemically Reacting Flows and Transport Phenomena, Kinetic Isotope Effects and Reaction Mechanisms, Advanced Experimental Techniques in Kinetics, Kinetic Modeling of Complex Systems.	**07**
II	**Reactor Design for Complex Reactions:** Non-Ideal Flow Patterns and Residence Time Distributions, Multi-Phase Reactors: Design and Analysis, Reactor Stability and Bifurcation Analysis, Dynamic Behavior of Chemical Reactors, Multiphase Reaction Engineering: Modeling and Simulation, Heterogeneous Catalytic Reactors: Design Challenges.	**07**
III	**Catalysis and Catalytic Reactors:** Advanced Concepts in Heterogeneous Catalysis, Surface Chemistry and Catalyst Characterization Techniques, Kinetic and Transport Phenomena in Catalytic Reactors, Advanced Catalytic Materials and Nanostructured Catalysts, Reactor Engineering for Selective Catalysis.	**07**

IV	**Multiphase Reaction Engineering:** Fundamentals of Multiphase Reaction Engineering, Gas-Liquid-Solid Reactors: Design and Analysis, Mass Transfer and Interfacial Phenomena in Multiphase Systems, Hydrodynamics of Multiphase Reactors, Scale-Up and Scale-Down of Multiphase Reactors.	**07**
V	**Advanced Topics in Reaction Engineering:** Enzymatic Reaction Engineering and Biocatalysis, Electrochemical Reaction Engineering, Photocatalysis and Advanced Oxidation Processes, Reaction Engineering for Energy Conversion, Process Intensification and Microreactor Technology, Reactor Engineering for Sustainable Processes.	**06**
VI	**Case Studies and Applications**: Industrial Case Studies: Petrochemical, Pharmaceutical, Fine Chemicals, Environmental Applications: Air Pollution Control, Water Treatment, Energy Conversion and Storage Systems, Future Directions in Reaction Engineering.	**05**
Text Books		
1.	Levenspiel, O. (2001). Chemical Reaction Engineering (3rd ed.). John Wiley & Sons.	
2.	Fogler, H. S. (2016). Elements of Chemical Reaction Engineering (5th ed.). Prentice Hall.	
3.	Hill, C. G. (2018). An Introduction to Chemical Engineering Kinetics and Design. John Wiley & Sons.	
4.	Walas S. M. (1959). Reaction Kinetics for Chemical Engineers. McGraw Hill.	
Reference Books		
1.	Froment, G. F., Bischoff, K. B., & De Wilde, J. (2011). Chemical Reactor Analysis and Design. John Wiley & Sons.	
2.	Carberry, J. J. (1976). Chemical and Catalytic Reaction Engineering. McGraw-Hill Education.	
3.	Holland, C. D., & Anthony, R. (2000). Chemical Kinetics and Reaction Dynamics. Dover Publications.	
4.	Chorkendroff, I., NiemountsVerdriet, J.W. (2006). Concepts of Modern Catalysis and Kinetics. John Wiley and Sons.	
Useful web links		
1.	https://onlinecourses.nptel.ac.in/noc23_ch66/preview	
2.	https://www.aiche.org	

<table>
<tr><td>Year,Program, Semester</td><td colspan="7">B. Tech Chemical Engineering (Honors/Honors with Research)</td></tr>
<tr><td>Course Code</td><td colspan="7">HN-3</td></tr>
<tr><td>Course Category</td><td colspan="7">Core</td></tr>
<tr><td>Course title</td><td colspan="7">Advanced Chemical Engineering Thermodynamics</td></tr>
<tr><td rowspan="2">Teaching Scheme and Credits</td><td>L</td><td>T</td><td>P</td><td colspan="2">Total Contact Hours</td><td colspan="2">Total Credits</td></tr>
<tr><td>03</td><td>-</td><td>-</td><td colspan="2">03</td><td colspan="2">03</td></tr>
<tr><td rowspan="2">Evaluation Scheme</td><td colspan="2">ISE</td><td>ESE</td><td>IOE</td><td>IPE</td><td>EOE</td><td>EPE</td><td>Total</td></tr>
<tr><td colspan="2">30</td><td>70</td><td>-</td><td>-</td><td>-</td><td>-</td><td>100</td></tr>
<tr><td>Pre-requisites(if any)</td><td colspan="7">PCC 212</td></tr>
<tr><td>Course Rationale</td><td colspan="7">The course is designed to provide students with an in-depth understanding of thermodynamic principles and their applications in chemical engineering. The course covers advanced topics such as phase equilibria, chemical reaction thermodynamics, and non-ideal systems. Emphasis is placed on theoretical concepts, problem-solving techniques, and practical applications in process design and optimization.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">The Course Teacher will
1. Provide a thorough understanding of advanced thermodynamic principles and their application in chemical engineering.
2. Develop students' ability to analyze phase equilibria in complex systems and apply thermodynamic models for prediction.
3. Enable understanding of thermodynamics of chemical reactions and their role in process design and optimization.
4. Familiarize students with thermodynamic properties and behaviors of mixtures, including ideal and non-ideal solutions.
5. Introduce thermodynamics of complex systems like electrolytes, polymers, colloids, and supercritical fluids.
6. Explore advanced topics in thermodynamics: statistical thermodynamics, non-equilibrium processes, and recent research developments.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">Upon completion of this course, student should be able to
1. Apply thermodynamic principles to analyze and resolve issues concerning energy, work, and heat transfer.
2. Predict phase behavior and conduct calculations for vapor-liquid, liquid-liquid, and solid-liquid equilibria.
3. Assess chemical reaction equilibria utilizing thermodynamic principles and equilibrium constants.
4. Utilize mixture thermodynamics concepts for separation processes and</td></tr>
</table>

	phase diagram analysis. 5. Comprehend the thermodynamics of complex systems such as electrolyte solutions, polymer blends, and colloidal suspensions. 6. Demonstrate awareness of recent advancements and research trends in thermodynamics and their implications for chemical engineering practice.

Course Outcome and Program Outcome Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO 12
CO 1	3	3	3	2	2	1	-	-	2	-	-	-
CO 2	3	3	3	2	2	1	-	-	2	-	-	-
CO 3	-	3	3	1	-	3	-	3	2	-	-	-
CO 4	3	-	3	3	-	-	3	1	-	-	-	-
CO 5	3	3	-	-	3	-	1	-	-	-	-	3
CO 6	1	3	-	3	-	-	-	3	3	-	3	-

Level of Mapping as: Low 1, Moderate 2, High 3

Unit No.	Course Content	Hours
I	**Review of Fundamentals:** Basic Concepts of Thermodynamics: Energy, Work, and Heat, Laws of Thermodynamics: First Law, Second Law, and Third Law, Thermodynamic Properties and State Functions, Phase Equilibria: Single Component and Multi-component Systems, Thermodynamic Diagrams and Phase Rule, Introduction to Thermodynamic Modeling Software Tools.	06
II	**Phase Equilibria and Chemical Potential:** Gibbs Phase Rule and Phase Equilibrium Criteria, Vapor-Liquid Equilibrium (VLE) Calculations, Liquid-Liquid Equilibrium (LLE) Calculations, Solid-Liquid Equilibrium (SLE) and Solid-Vapor Equilibrium (SVE), Activity Coefficients and Fugacity, Ideal and Non-Ideal Solutions, Phase Equilibrium in Non-Ideal Systems, Applications of Phase Equilibria in Chemical Engineering.	07
III	**Chemical Reaction Thermodynamics:** Thermodynamic Properties of Ideal and Real Gases, Chemical Potential and Reaction Equilibrium, Equilibrium Constant and Reaction Quotient, Effect of Temperature and Pressure on Chemical Equilibrium, Reaction Enthalpy, Entropy, and Gibbs Free Energy Change, Application of Chemical Reaction Thermodynamics in Process Design.	06
IV	**Thermodynamics of Mixtures:** Ideal Gas Mixtures and Dalton's Law, Partial Molar Properties and Gibbs-Duhem Equation, Ideal and Non-Ideal Liquid Mixtures, Raoult's Law and Henry's Law, Excess Properties: Excess Enthalpy, Excess Gibbs Free Energy, Activity Coefficients Models: Wilson, NRTL, UNIQUAC, Phase Diagrams of Binary Mixtures, Applications of Mixture Thermodynamics in Separation Processes.	08

V	**Thermodynamics of Complex Systems:** Thermodynamics of Electrolyte Solutions, Debye-Hückel Theory and Activities in Electrolyte Solutions, Thermodynamics of Polymer Solutions and Blends, Colloidal Thermodynamics and Surface Tension, Thermodynamics of Supercritical Fluids 5.6 Thermodynamics of Biological Systems.	**06**
VI	**Advanced Topics in Thermodynamics:** Thermodynamics and Molecular Simulation Techniques, Non-Equilibrium Thermodynamics: Irreversible Processes, Entropy Production, Thermodynamics of Nanomaterials and Nanoparticles, Thermodynamics of Complex Reactions: Catalysis, Combustion, Recent Advances in Thermodynamics Research and Applications, Case Studies and Research Projects in Advanced Thermodynamics.	**06**
Text Books		
1.	Smith, J. M., Van Ness, H. C., & Abbott, M. M. (2005). Introduction to Chemical Engineering Thermodynamics. McGraw-Hill Education.	
2.	Sandler, S. I. (2006). Chemical, Biochemical, and Engineering Thermodynamics. John Wiley & Sons.	
Reference Books		
1.	Prausnitz, J. M., Lichtenthaler, R. N., & Azevedo, E. G. (1999). Molecular Thermodynamics of Fluid-Phase Equilibria. Prentice Hall.	
2.	Debye, P. J., & Huckel, E. (1923).The Theory of Electrolytes. Dover Publications.	
Useful web links		
1.	https://www.chemeurope.com/en/encyclopedia/Thermodynamics.html	
2.	https://web.mit.edu/thermodynamics/	
3.	https://trc.nist.gov/	
4.	https://nptel.ac.in/courses/103104151	
5.	https://onlinecourses.nptel.ac.in/noc22_ch22/preview	

<table>
<tr><td>Year,Program, Semester</td><td colspan="8">B. Tech Chemical Engineering (Honors/Honors with Research)</td></tr>
<tr><td>Course Code</td><td colspan="8">HN-4</td></tr>
<tr><td>Course Category</td><td colspan="8">Core</td></tr>
<tr><td>Course title</td><td colspan="8">Process Optimization and Control</td></tr>
<tr><td rowspan="2">Teaching Scheme and Credits</td><td>L</td><td>T</td><td>P</td><td colspan="3">Total Contact Hours</td><td colspan="2">Total Credits</td></tr>
<tr><td>03</td><td>-</td><td>-</td><td colspan="3">03</td><td colspan="2">03</td></tr>
<tr><td rowspan="2">Evaluation Scheme</td><td colspan="2">ISE</td><td>ESE</td><td>IOE</td><td>IPE</td><td>EOE</td><td>EPE</td><td>Total</td></tr>
<tr><td colspan="2">30</td><td>70</td><td>-</td><td>-</td><td>-</td><td>-</td><td>100</td></tr>
<tr><td>Pre-requisites(if any)</td><td colspan="8">ESC 321</td></tr>
<tr><td>Course Rationale</td><td colspan="8">The course is designed to provide students with advanced knowledge and skills in optimizing and controlling industrial processes. The course will cover topics such as optimization techniques, advanced control strategies, process modeling, simulation, and real-time optimization. Emphasis will be placed on practical applications, case studies, and hands-on experience using industry-standard software tools.</td></tr>
<tr><td>Course Objectives</td><td colspan="8">The Course Teacher will
1. Develop a comprehensive understanding of process optimization principles and techniques in industrial settings.
2. Explore advanced control strategies and their applications for optimizing complex industrial processes.
3. Develop and implement mathematical models for process simulation and optimization.
4. Introduce students to real-time optimization concepts and techniques for improving process performance dynamically.
5. Familiarize students with data analytics tools and methodologies for analyzing process data and optimizing industrial processes.
6. Analyze case studies and industrial applications to understand the practical challenges and solutions in process optimization and control.</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">Upon completion of this course, student should be able to
1. Identify and explain key concepts and principles of process optimization.
2. Design and implement suitable control schemes for improving process performance.
3. Utilize process models for optimizing process parameters and predicting system behavior.
4. Implement real-time optimization algorithms to dynamically adjust process variables for optimal performance.</td></tr>
</table>

	5. Utilize data analytics techniques to analyze process data and identify optimization opportunities. 6. Evaluate case studies and industrial applications to understand the practical implications of process optimization and control.

Course Outcome and Program Outcome Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO 12
CO 1	3	2	2	-	1	-	-	-	-	-	-	-
CO 2	3	2	3	-	1	-	-	-	2	-	-	-
CO 3	3	2	3	-	1	-	-	-	-	-	-	-
CO 4	-	-	-	-	1	-	-	-	2	-	3	-
CO 5	-	-	-	-	-	-	-	-	2	-	-	-
CO 6	3	2	-	-	1	-	-	-	2	-	3	3

Level of Mapping as: Low 1, Moderate 2, High 3

Unit No.	Course Content	Hours
I	**Introduction to Process Optimization:** Overview of Process Optimization, Importance of Optimization in Industrial Processes, Types of Optimization Problems: Linear, Non-linear, Integer, Dynamic, Optimization Techniques: Gradient-based, Evolutionary Algorithms, Swarm Intelligence, Sensitivity Analysis and Uncertainty Quantification, Optimization Software Tools: MATLAB, GAMS, Aspen Plus, Case Studies in Process Optimization, Optimization under Constraints: Economic, Environmental, Safety.	**07**
II	**Advanced Control Strategies:** Fundamentals of Process Control, PID Control and Tuning Methods, Advanced Control Techniques: Model Predictive Control (MPC), Adaptive Control, Robust Control, Control System Design and Stability Analysis, Multivariable Control Systems, Hierarchical and Decentralized Control, Control System Implementation and Integration with Plant Systems, Case Studies in Advanced Control Strategies.	**07**
III	**Process Modeling and Simulation:** Principles of Process Modeling, Types of Process Models: Empirical, Mechanistic, Data-driven, Model Development Techniques: Regression Analysis, System Identification, First Principles Modeling, Simulation Software Tools: Aspen HYSYS, CHEMCAD, COMSOL, Dynamic Simulation and Transient Analysis, Model Validation and Verification.	**07**
IV	**Real-Time Optimization:** Introduction to Real-Time Optimization (RTO), RTO Framework: Optimization Problem Formulation, Objective Functions, Constraints, Online Optimization Algorithms: Sequential Quadratic Programming (SQP), Interior Point Methods, Integration of RTO with Process Control Systems, Case Studies of Real-Time Optimization Applications, Challenges and Future Directions in RTO.	**06**

V	**Data Analytics for Process Optimization:** Introduction to Data Analytics in Process Optimization, Data Preprocessing Techniques: Cleaning, Transformation, Reduction, Supervised and Unsupervised Learning Algorithms: Regression, Clustering, Classification, Predictive Analytics and Machine Learning Models, Big Data Analytics and Industrial Internet of Things (IIoT), Applications of Data Analytics in Process Optimization.	**06**
VI	**Case Studies and Industrial Applications:** Optimization and Control Challenges in Chemical Process Industries, Optimization in Petrochemical and Refining Processes, Advanced Control Strategies in Power Plants and Energy Systems, Process Optimization in Pharmaceutical and Biotechnology Industries, Future Trends and Innovations in Process Optimization and Control.	**06**
Text Books		
1.	Edgar, T. F., Himmelblau, D. M., & Lasdon, L. S. (2001). Optimization of Chemical Processes. McGraw-Hill Education.	
2.	Seborg, D. E., Mellichamp, D. A., Edgar, T. F., & Doyle III, F. J. (2010). Process Dynamics and Control. John Wiley & Sons.	
3.	Romagnoli, J. A., & Palazoglu, A. (2007). Modeling and Control of Batch Processes, Springer.	
4.	Stephanopoulos, G. (2006). Chemical Process Control: An introduction to Theory and Practice. Dorling Kindersley Pvt Ltd.	
Reference Books		
1.	Shinskey, F. G. (2017). Process Control: A Practical Approach. CRC Press.	
2.	Chauhan, R., & Singh, R. (2019). Data Analytics Techniques for Process Optimization and Control. CRC Press.	
3.	Biegler, L. T., Grossmann, I. E., & Westerberg, A. W. (1997). Systematic Methods of Chemical Process Design. Prentice Hall.	
Useful web links		
1.	https://www.aiche.org/academy/topics/process-control-optimization	
2.	https://nptel.ac.in/courses/111105039	
3.	https://onlinecourses.nptel.ac.in/noc21_ch02/preview	
4.	https://onlinecourses.nptel.ac.in/noc21_ch38/preview	

<table>
<tr><td>Year,Program, Semester</td><td colspan="7">B. Tech Chemical Engineering (Honors/Honors with Research)</td></tr>
<tr><td>Course Code</td><td colspan="7">HN-5</td></tr>
<tr><td>Course Category</td><td colspan="7">Program Core</td></tr>
<tr><td>Course title</td><td colspan="7">Bioprocess Engineering</td></tr>
<tr><td rowspan="2">Teaching Scheme and Credits</td><td>L</td><td>T</td><td>P</td><td colspan="2">Total Contact Hours</td><td colspan="2">Total Credits</td></tr>
<tr><td>03</td><td>-</td><td>-</td><td colspan="2">03</td><td colspan="2">03</td></tr>
<tr><td rowspan="2">Evaluation Scheme</td><td colspan="2">ISE</td><td>ESE</td><td>IOE</td><td>IPE</td><td>EOE</td><td>EPE</td><td>Total</td></tr>
<tr><td colspan="2">30</td><td>70</td><td>-</td><td>-</td><td>-</td><td>-</td><td>100</td></tr>
<tr><td>Pre-requisites(if any)</td><td colspan="7">BSC 211, BSC 221, PCC 312</td></tr>
<tr><td>Course Rationale</td><td colspan="7">The course focuses on the application of engineering principles to biological systems and processes. The course covers topics such as microbial growth kinetics, bioreactor design, downstream processing, and fermentation technology. Emphasis is placed on understanding the principles underlying bioprocess engineering, as well as the application of advanced techniques in biotechnology and biochemical engineering.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">The Course Teacher will
1. Introduce students to the fundamental principles and concepts of bioprocess engineering.
2. Develop student’s understanding of bioreactor design, operation, and scale-up for various bioprocesses.
3. Equip students with the knowledge and skills to optimize microbial fermentation processes for the production of biomolecules.
4. Familiarize students with enzyme kinetics, biocatalysis, and the design of enzyme and cell bioprocessing systems.
5. Enable students to monitor and control bioprocesses effectively using advanced analytical techniques and control strategies.
6. Explore emerging trends and technologies in bioprocess engineering and their applications in industry and research.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">Upon completion of this course, student should be able to
1. Explain the fundamental principles and concepts of bioprocess engineering.
2. Design and analyze bioreactors for different bioprocess applications and Scale up bioprocesses to industrial scale.
3. Optimize fermentation conditions for maximum biomass and product yield.
4. Design enzyme immobilization systems and cell culture techniques and Understand enzyme kinetics and biocatalysis principles.
5. Monitor bioprocess parameters and analyze process data using</td></tr>
</table>

	advanced analytical techniques. 6. Evaluate the potential applications of bioprocess engineering in various industries and research fields.

Course Outcome and Program Outcome Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO 12
CO 1	3	2	2	-	1	-	-	-	-	-	-	-
CO 2	3	2	3	-	1	-	-	-	2	-	-	-
CO 3	3	2	3	3	-	-	-	-	2	-	-	-
CO 4	-	-	-	-	3	-	-	-	-	-	2	-
CO 5	-	-	-	-	1	-	-	-	2	-	-	-
CO 6	3	2	-	-	1	-	-	-	2	-	2	3

Level of Mapping as: Low 1, Moderate 2, High 3

Unit No.	Course Content	Hours
I	**Introduction to Bioprocess Engineering:** Overview of Bioprocess Engineering, Scope and Applications of Bioprocess Engineering, Fundamentals of Microbiology for Bioprocess Engineering, Biomass Growth Kinetics: Monod Model and Beyond, Introduction to Fermentation Technology, Industrial Applications of Bioprocess Engineering.	06
II	**Bioreactor Design and Operation:** Types of Bioreactors: Batch, Fed-batch, Continuous, Bioreactor Design Considerations: Mixing, Aeration, Sterilization, Scale-Up and Scale-Down of Bioreactors, Bioreactor Instrumentation and Control, Modeling and Simulation of Bioreactor Systems, Case Studies in Bioreactor Design and Operation, Advanced Bioreactor Technologies: Membrane Bioreactors, Photobioreactors, Upstream Processing and Cell Culture Techniques.	08
III	**Microbial Fermentation Processes:** Microbial Fermentation Pathways: Aerobic and Anaerobic, Optimization of Fermentation Conditions: Media Formulation, pH, Temperature, Kinetics of Microbial Growth and Product Formation, Microbial Strain Improvement Techniques: Mutagenesis, Recombinant DNA Technology, Metabolic Engineering for Enhanced Productivity, Downstream Processing: Recovery and Purification of Fermentation Products.	06
IV	**Enzyme and Cell Bioprocessing:** Enzyme Kinetics and Biocatalysis, Enzyme Immobilization Techniques, Cell Culture Techniques: Batch, Continuous, Perfusion, Bioreactor Design for Enzyme and Cell Bioprocessing, Downstream Processing of Enzymes and Biomolecules, Applications of Enzyme and Cell Bioprocessing in Industry.	06
V	**Bioprocess Monitoring and Control:** Monitoring Biomass Concentration and Metabolite Production, Sensors and Analytical Techniques in Bioprocess	06

	Monitoring, Real-Time Process Control Strategies, Feedback and Feedforward Control Systems, Process Optimization Techniques: Response Surface Methodology, DoE, Quality Control and Regulatory Compliance in Bioprocessing.	
VI	**Emerging Trends in Bioprocess Engineering:** Bioprocess Intensification: Miniaturization and Microfluidics, Synthetic Biology and Bioinformatics in Bioprocessing, Biorefinery Concepts and Sustainable Bioprocessing, Biopharmaceutical Production and Personalized Medicine, Bioprocessing for Renewable Energy: Biofuels, Biogas, Future Challenges and Opportunities in Bioprocess Engineering.	**07**
Text Books		
1.	Shuler, M. L., & Kargi, F. (2001). Bioprocess Engineering: Basic Concepts. Prentice Hall.	
2.	Doran, P. M. (2016). Bioprocess Engineering Principles. Elsevier.	
3.	Blanch, H. W., & Clark, D. S. (1996). Biochemical Engineering. Marcel Dekker Inc.	
Reference Books		
1.	Bailey, J. E., & Ollis, D. F. (1986). Biochemical Engineering Fundamentals. McGraw-Hill Education.	
2.	Stephanopoulos, G., Aristidou, A., & Nielsen, J. (1998). Metabolic Engineering: Principles and Methodologies. Academic Press.	
Useful web links		
1.	https://nptel.ac.in/courses/102106086	
2.	https://nptel.ac.in/courses/102106022	
3.	https://onlinecourses.nptel.ac.in/noc22_bt09/preview	

<table>
<tr><td>Year,Program, Semester</td><td colspan="7">B. Tech Chemical Engineering (Honors/Honors with Research)</td></tr>
<tr><td>Course Code</td><td colspan="7">HN-AEC1</td></tr>
<tr><td>Course Category</td><td colspan="7">Ability Enhancement Course</td></tr>
<tr><td>Course title</td><td colspan="7">Advanced Laboratory Practice</td></tr>
<tr><td rowspan="2">Teaching Scheme and Credits</td><td>L</td><td>T</td><td>P</td><td colspan="2">Total Contact Hours</td><td colspan="2">Total Credits</td></tr>
<tr><td>-</td><td>-</td><td>04</td><td colspan="2">04</td><td colspan="2">02</td></tr>
<tr><td rowspan="2">Evaluation Scheme</td><td colspan="2">ISE</td><td>ESE</td><td>IOE</td><td>IPE</td><td>EOE</td><td>EPE</td><td>Total</td></tr>
<tr><td colspan="2">-</td><td>-</td><td>-</td><td>50</td><td>50</td><td>-</td><td>100</td></tr>
<tr><td>Pre-requisites(if any)</td><td colspan="7">BSC211, PCC 211, PCC 222, PCC 221, , PCC311, PCC312, PCC321.</td></tr>
<tr><td>Course Rationale</td><td colspan="7">This course is designed to provide students with advanced laboratory skills and techniques relevant to chemical engineering. The focus will be on hands-on experiments, data analysis, and the application of theoretical concepts to practical situations.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">The course is aimed at
1. Explain theoretical knowledge to design and conduct advanced experiments in chemical engineering.
2. Enhance skills in data acquisition, analysis, and interpretation.
3. Develop proficiency in utilizing advanced laboratory equipment and techniques.
4. Promote teamwork, communication, and presentation skills through collaborative laboratory projects.
5. Understand safety protocols and ethical considerations in a laboratory setting.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">Upon completion of this course, student should be able to
1. Design and execute experiments independently, demonstrating a comprehensive understanding of the underlying principles.
2. Analyze and interpret experimental data using statistical methods and present results effectively.
3. Demonstrate proficiency in using advanced laboratory equipment and techniques, including spectroscopy, chromatography.
4. Work collaboratively in a team setting, fostering effective communication and problem-solving skills.
5. Tackle on to safety protocols and ethical standards in a laboratory environment.</td></tr>
</table>

Course Outcome and Program Outcome Mapping

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3	3	2	1	-	-	-	3	-	-	2
CO 2	1	3	2	2	-	-	-	-	2	3	-	2
CO 3	3	1	3	2	-	-	-	-	3	-	-	2
CO 4	-	2	-	3	-	-	-	3	3	2	3	2
CO 5	-	-	-	-	3	-	3	3	3	-	-	-

Level of Mapping as: Low 1, Moderate 2, High 3

General Instructions: Any 6 experiments to be performed from the list, any 2 experiments to be studied as demonstration.

Sr.No.	Details of Experiment
1.	Separation and Identification of Organics in an unknown mixture by using gas chromatography-mass spectrometry (GC-MS)
2.	Analysis of complex mixtures using High-performance liquid chromatography (HPLC)
3.	Design and analysis of particle size reduction processes using nano ball mill
4.	Detection of functional groups using FTIR Analysis
5.	Spectrophotometric analysis of a given mixture
6.	To study the water flux and fouling behaviour of membrane
7.	To study the Reverse Osmosis membrane performance
8.	To study the Performance of an Ultra filtration Flat Sheet Membrane
9.	Analysis of an unknown mixture using Ultrasound probe Sonicator
10.	Study of pervaporation process for Dehydration of ethanol
11.	Design and evaluation of wastewater treatment processes
12.	Determination of metallic impurities in waste waters by Atomic Absorption Spectrometry
13.	Performance of a Calandria Evaporator
14.	RTD in mixed flow reactors in series
15.	Power consumption in an agitated vessel

Text Books/ Reference Books	
1.	McCabe, W. L., Smith, J. C., Harriot, P. (2021). Unit Operations of Chemical Engineering. 7th edition. McGraw Hill.
2.	Green, D. and Perry, R. (2007). Perry's Chemical Engineers' Handbook. 8th Edition. McGraw-Hill Professional Pub.
3.	Mishra, K., Dash, A., Tripathy, S., Jena, D. (2023). Instrumental Methods of Analysis. Lab Manual. Taran publication.
4.	Stone, D. C. (2003-2018). Instrumental Analysis. Laboratory Manual. CHM 317H1.
5.	Braithwaite, A., Smith, F. J. (1996). Chromatographic Methods. Blackie Academic and Professional. 5th edition.
6.	Coulson, J. M., Richardson, J. F., and Sinnott, R. K. (2005). Chemical Engineering: Chemical engineering design. Vol 6. ,4th edition. Elsevier Butterworth-Heinemann.
7.	Chatwal, G. R., Anand S. K. (2002). Instrumental Methods of Chemical Analysis. 5th edition. Himalaya Publishing House.
Useful Web links	
1.	NIOSH pocket guide: http://www.cdc.gov/niosh/npg/

Shivaji University, Kolhapur
Department of Technology

MDM Featured B. Tech (Chemical Engineering) Honors with Research

Teaching and Evaluation Scheme

Sr. No.	Category	Code	Course Title	Hours per week			Contact Hours	Credits	Evaluation Scheme	
									Theory	Practical
				L	T	P			ISE:ESE	IE:EE
1.	SWAYAM (NPTEL) or any other MOOCs Or Self-study mode with University's End Semester Examination (Program Core Courses)	HNR- 1	Research Methodology	03	-	-	03	03	30:70	00:00
2.		HNR- 2	Advanced Reaction Engineering	03	-	-	03	03	30:70	00:00
3.		HNR – 3	Advanced Chemical Engineering Thermodynamics	03	-	-	03	03	30:70	00:00
4.		HNR – 4	Process Optimization and Control	03	-	-	03	03	30:70	00:00
5.		HNR – 5	Bioprocess Engineering	03	-	-	03	03	30:70	00:00
6.	Ability Enhancement Course	HNR-AEC1	Advanced Laboratory Practice	-	-	04	04	02	-	50:50
7.	Project Based Learning	HNR –PBL	*Additional Research Project	-	-	06	06	03	-	50:50
				-	-	-	-	20	500	200
			Total Hours	15	-	10	25	-	-	-

Note: For Honors with Research, the courses and the credits as that for Honors will be the same. In addition, there will be 3 credits against an additional research project completion with success in publishing at least one research paper in a peer reviewed journal.

<table>
<tr><td>Year, Program, Semester</td><td colspan="8">B. Tech Chemical Engineering (Honors with Research)</td></tr>
<tr><td>Course Code</td><td colspan="8">HNR-PBL</td></tr>
<tr><td>Course Category</td><td colspan="8">Core</td></tr>
<tr><td>Course title</td><td colspan="8">Additional Research Project</td></tr>
<tr><td rowspan="2">Teaching Scheme and Credits</td><td>L</td><td>T</td><td>P</td><td colspan="2">Total Contact Hours</td><td colspan="3">Total Credits</td></tr>
<tr><td>-</td><td>-</td><td>06</td><td colspan="2">06</td><td colspan="3">03</td></tr>
<tr><td rowspan="2">Evaluation Scheme</td><td colspan="2">ISE</td><td>ESE</td><td>IOE</td><td>IPE</td><td>EOE</td><td>EPE</td><td>Total</td></tr>
<tr><td colspan="2">-</td><td>-</td><td>-</td><td>50</td><td>50</td><td>-</td><td>100</td></tr>
<tr><td>Pre-requisites(if any)</td><td colspan="8">All the courses underlying MDM Featured B.Tech (Chemical Engineering) Major.</td></tr>
<tr><td>Course Rationale</td><td colspan="8">The Additional Research Projects course allows B.Tech Chemical Engineering Major students to pursue advanced research, enhancing their skills and contributing to the field. This course aims to foster critical thinking, problem-solving skills, and research acumen among students while allowing them to explore topics of personal interest and relevance to the discipline. Completion of this course and the attainment of the B.Tech Honors with research Degree make students eligible for Ph.D. studies, facilitating their academic and research progression in chemical engineering or related fields.</td></tr>
<tr><td>Course Objectives</td><td colspan="8">The Course Teacher will
1. To facilitate exploration of focused research areas in chemical engineering.</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">Upon completion of this course, student should be able to
1. Formulate research questions and design methodologies.
2. Analyze and interpret data effectively.
3. Synthesize literature to contextualize research.
4. Present findings effectively through oral and written communication.
5. Demonstrate critical thinking and problem-solving in research.</td></tr>
</table>

Course Outcome and Program Outcome Mapping

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	-	-	-	3	-	-	-	-	2	-	-	2
CO 2	3	-	-	3	2	-	-	-	-	-	-	-

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

Level of Mapping as: Low 1, Moderate 2, High 3

Unit No.	Course Content
I	**Topic Selection and Proposal Development:** • Identifying research gaps and formulating research questions. • Writing a research proposal outlining objectives, methodology, and expected outcomes. • Conducting rigorous ‘ research topic relevant literature survey’
II	**Research Methodologies:** • Introduction to research design and planning. • Data collection techniques and tools. • Statistical analysis methods.
III	**Conducting Research:** • Implementing the proposed methodology. • Data collection, analysis, and interpretation. • Troubleshooting research challenges.
IV	**Presentation and Communication:** • Preparing and delivering oral presentations. • Writing research reports following standard scientific formats. • Communicating research findings effectively to diverse audiences.

Course Assessment Method

Assessment in this course will be based on the following criteria:

1. Research Proposal (20%): Evaluation of the clarity, feasibility, and originality of the research proposal.
2. Research Progress (30%): Assessment of the student's progress in conducting the research project, including data collection, analysis, and interpretation.
3. Final Research Report (30%): Evaluation of the quality of the written research report, including organization, clarity, depth of analysis, and adherence to scientific standards.
4. Oral Presentation (20%): Assessment of the student's ability to effectively communicate research findings through a formal presentation.

Additionally, continuous engagement, participation in research discussions, and adherence to deadlines will be considered in the overall assessment of the course.

Text Books/ Reference Books

1.	Towler, G., & Sinnott, R. K. (2012). Chemical Engineering Design: Principles, Practice, and Economics of Plant and Process Design.
2.	Crowl, D. A., & Louvar, J. F. (2011). Chemical Process Safety: Fundamentals with Applications.

3.	McCabe, W. L., Smith, J. C., & Harriott, P. (2005). Unit Operations of Chemical Engineering.
4.	Geankoplis, C. J. (2003). Transport Processes and Separation Process Principles.
5.	Solen, K. A., & Harb, J. N. (2018). Introduction to Chemical Engineering: Tools for Today and Tomorrow.
6.	Smith, J. M., Van Ness, H. C., & Abbott, M. M. (2005). Chemical Engineering Kinetics.
7.	Foust, A. S., Wenzel, L. A., Clump, C. W., & Maus, L. (1980). Principles of Unit Operations.
8.	Fogler, H. S. (2016). Essentials of Chemical Reaction Engineering. 4th Edtn.
9.	Smith, J. M., Van Ness, H. C., Abbott, M. M., & Swihart, M. (2005). Chemical Engineering Thermodynamics.
10.	Coughanowr, D. R., & LeBlanc, S. E. (2009). Process Systems Analysis and Control.

Shivaji University
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Department of Technology

As per NEP2020 guidelines

Pool of Specialization Minors for
MDM Featured B. Tech (Chemical Engineering), Detailed Curriculum, w.e.f 2024-25

Specialization Minor
In
Pharmaceutical Technology
For
B.Tech (Chemical Engineering)

Shivaji University, Kolhapur

Department of Technology

Specialization Minor in Pharmaceutical Technology

Teaching & Evaluation Scheme

Sr. No.	Category	Course Code	Course Title	Hours per week			Contact Hours	Credits	Evaluation Scheme	
									Theory	Practical
				L	T	P			ISE:ESE	IE:EE
1.	Preferably on SWAYAM (NPTEL) or any other MOOCs (Minor Program Core) Or In a Face-to-Face mode	SPM 1.1	Introduction to Pharmaceutical Engineering	03	-	-	03	03	30:70	00:00
2.		SPM 1.2	Pharmaceutical Dosage Forms and Drug Delivery Systems	03	-	-	03	03	30:70	00:00
3.		SPM1.3	Pharmaceutical Quality Assurance and Regulatory Compliance	03	-	-	03	03	30:70	00:00
4.	Minor Program Based Internship	SPM1.4	Pharmaceutical Industry Internship	One Month				03	00:00	50:50
5.	Project Based Learning	SPM 1.5	Mini Project	-	-	-	-	02	-	50:50
				-	**-**	**-**	**-**	**14**	**300**	**200**
			Total Hours	**09**	**00**	**00**	**09**	**-**	**-**	**-**

Note: If opted the Specialization Minor Program, Internship may be planned during winter or summer vacation days after 4th semester while respective evaluations will appear on a separate mark sheet.

Specialization Minor I: Pharmaceutical Technology

Year, Program, Semester	Specialization Minor I, 4th Semester onwards						
Course Code	SPM-1.1						
Course Category	Specialization Minor Program Core						
Course Title	**Introduction to Pharmaceutical Engineering**						
Teaching Scheme and Credits	**L**	**T**	**P**	**Total Contact Hours**		**Total Credits**	
	03	-	-	03		03	
Evaluation Scheme	**ISE**	**ESE**		**IOE**	**IPE**	**EOE**	**EPE**	**Total**
	30	70		-	-	-	-	100
Pre-requisites(if any)	Basics of unit processes and unit operations.						
Course Rationale	This course introduces students to the interdisciplinary field of pharmaceutical engineering, emphasizing the integration of engineering principles with pharmaceutical science to develop safe and effective drug products.						
Course Objectives	The course teacher will 1. Explain the basic concepts and principles of pharmaceutical engineering. 2. Discuss the stages of drug development and the role of engineering in each stage. 3. Illustrate the key challenges and considerations in pharmaceutical manufacturing processes. 4. Describe the impact of regulatory requirements on pharmaceutical engineering practices.						
Course Outcomes	The student will be able to 1. Understand the fundamental principles of pharmaceutical engineering. 2. Identify the stages involved in drug development and theirengineering aspects. 3. Explore the challenges associated with pharmaceutical manufacturing and propose solutions. 4. Evaluate the importance of regulatory compliance in pharmaceutical engineering.						

Course Outcome and Program Outcome Mapping

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	-	-	2	2	1	-	-	-	-	-	-
CO 2	-	3	-	3	2	1	-	-	-	-	-	-
CO 3	-	-	3	3	2	2	-	-	-	-	-	-
CO 4	-	-	-	-	-	3	1	2	3	3	-	-

Level of Mapping as: Low 1, Moderate 2, High 3

Unit No.	Course Content	Hours
I	**Introduction to Pharmaceutical Engineering** Overview of Pharmaceutical Engineering, Interdisciplinary Nature of the Field, Importance of Engineering in Drug Development and Manufacturing	06
II	**Drug Development Process** Drug Discovery and Preclinical Development, Formulation Development, ClinicalTrials and Regulatory Approval Processes	06
III	**Pharmaceutical Manufacturing Technologies** Basics of Pharmaceutical Manufacturing, Unit Operations in Manufacturing Processes, Process Optimization and Scale-Up	08
IV	**Quality Control and Assurance in Pharmaceutical Engineering** Principles of Quality Control and Assurance, Good Manufacturing Practices (GMP),Quality Control Techniques and Methods	06
V	**Regulatory Requirements for Pharmaceutical Products** Regulatory Agencies and Guidelines (FDA, EMA, etc.), Compliance Requirements for Pharmaceutical Manufacturing Regulatory Challenges and Considerations	04
VI	**Case Studies and Industry Applications** Real-World Case Studies in Pharmaceutical Engineering, Industry Applications and Innovations, Future Trends in Pharmaceutical Engineering	06
	Text Books	
1.	Smith, J., & Johnson, A. (Eds.). (2018). Pharmaceutical Engineering: Principles and Applications. Wiley.	
	Reference Books	
1.	Carter, R., & Pritchard, J. (2017). Introduction to Pharmaceutical Unit Operations. CRC Press	
2.	Roberts, M., & Rowe, R. (2019). Pharmaceutical Dosage Forms: Tablets. CRC Press.	

Year, Program, Semester	Specialization Minor I, 4th Semester onwards											
Course Code	SPM-1.2											
Course Category	Specialization Minor Program Core											
Course Title	**Pharmaceutical Dosage Forms and Drug Delivery Systems**											
Teaching Scheme and Credits	**L**	**T**	**P**	**Total Contact Hours**					**Total Credits**			
	03	-	-	03					03			
Evaluation Scheme	**ISE**	**ESE**		**IOE**		**IPE**			**EOE**	**EPE**	**Total**	
	30	70		-		-			-	-	100	
Pre-requisites(if any)	Basics of unit processes and unit operations											
Course Rationale	This course provides an in-depth exploration of pharmaceutical dosage forms and drug delivery systems, covering their design, formulation, and evaluation for safe and effective drug delivery.											
Course Objectives	The course teacher will 1. Explain the principles underlying different pharmaceutical dosage forms. 2. Describe the various drug delivery systems and their applications. 3. Illustrate factors influencing the selection and design of dosage forms and delivery systems. 4. Discuss methods for evaluating the performance and effectiveness of dosage forms and delivery systems.											
Course Outcomes	By the end of the course, students will be able to 1. Estimate the characteristics and properties of different pharmaceutical dosage forms. 2. Identify the principles and mechanisms of various drug deliverysystems. 3. Assess the suitability of dosage forms and delivery systems for specific drugs and patient populations 4. Apply analytical techniques to evaluate the performance of dosageforms and delivery systems.											

Course Outcome and Program Outcome Mapping

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	-	2	-	2	1	-	-	-	-	-	-
CO 2	3	-	2	3	2	-	-	-	-	-	-	-
CO 3	-	3	-	3	2	2	-	-	-	-	-	-
CO 4	-	-	-	3	3	-	-	-	2	-	-	2

Level of Mapping as: Low 1, Moderate 2, High 3

Unit No.	Course Content	Hours
I	**Solid Dosage Forms: Tablets and Capsules** Tablet Formulation and Manufacturing Excipients, granulation, compression, and coating. Capsule Formulation and Encapsulation Techniques Capsule types, formulation considerations, filling methods.	**06**
II	**Liquid Dosage Forms: Solutions, Suspensions, and Emulsions** Liquid Formulation Development Solvent selection, viscosity modifiers, preservatives., Suspension and Emulsion Preparation Particle size reduction, Emulsifiers, stabilizers.	**08**
III	**Parenteral Dosage Forms: Injections and Implants** Injectable Formulation Considerations Solubility, pH, osmolarity, and Sterility. Implantable Drug Delivery Systems Biodegradable polymers implant design, drug release kinetics.	**06**
IV	**Topical and Transdermal Drug Delivery Systems** Topical Formulations Creams, ointments, gels, and lotions, Transdermal Patch Design and Development Membrane permeation, adhesive selection, and drug release control.	**06**
V	**Controlled Release and Targeted Drug Delivery Systems** Controlled Release Mechanisms Matrix systems, reservoir systems osmotic pumps., Targeted Drug Delivery Strategies Ligand-mediated targeting, nanoparticle Carriers, liposomes.	**04**
VI	**Evaluation Methods for Pharmaceutical Dosage Forms and Delivery Systems** In vitro and in vivo Evaluation Techniques Dissolution testing, drug release profiles, bioavailability studies., Stability Testing and Shelf-Life Determination	**06**
Text Books		
1.	Banker, G. S., & Rhodes, C. T. (Eds.). (2016). Modern Pharmaceutics. CRC Press.	
Reference Books		
1.	Tyle, P. (2018). Drug Delivery to the Respiratory Tract. CRC Press.	
2.	Walters, K. A., & Hadgraft, J. (Eds.). (2018). Pharmaceutical Dosage Forms and Drug Delivery. CRC Press.	

Year, Program, Semester	Specialization Minor I, 4th Semester onwards												
Course Code	SPM-1.3												
Course Category	Specialization Minor Program Core												
Course Title	**Pharmaceutical Quality Assurance and Regulatory Compliance**												
Teaching Scheme and Credits	**L**	**T**	**P**	**Total Contact Hours**				**Total Credits**					
	03	-	-	03				03					
Evaluation Scheme	**ISE**		**ESE**	**IOE**		**IPE**		**EOE**		**EPE**		**Total**	
	30		70	-		-		-		-		100	
Pre-requisites(if any)	Basics of unit processes and unit operations												
Course Rationale	This course focuses on the principles of quality assurance and regulatory compliance in pharmaceutical manufacturing, emphasizing the importance of ensuring product quality and meeting regulatory standards												
Course Objectives	The course teacher will 1. Describe the concepts and principles of pharmaceutical quality assurance. 2. Discuss with regulatory requirements governing pharmaceutical manufacturing. 3. Develop skills for implementing quality controlmeasures in pharmaceutical production 4. Illustrate case studies and real-world examples of quality assurance and regulatory compliance issues in the pharmaceutical industry.												
Course Outcomes	By the end of the course, students will be able to 1. Explore the importance of quality assurance in pharmaceutical manufacturing. 2. Interpret and apply relevant regulatory guidelines and standards. 3. Implement quality control measures to ensure compliance with regulatory requirements. 4. Evaluate and propose solutions for quality assurance and regulatory compliance challenges in pharmaceutical manufacturing.												

Course Outcome and Program Outcome Mapping

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	-	-	-	-	-	-	2	-	-	2	1
CO 2	-	3	-	-	2	3	-	3	-	-	-	-
CO 3	-	-	3	-	-	2	-	2	2	-	-	-
CO 4	-	3	-	3	-	-	-	3	-	-	3	-

Level of Mapping as: Low 1, Moderate 2, High

Unit No.	Course Content	Hours
I	**Principles of Quality Assurance in Pharmaceutical Manufacturing** Definition of quality assurance, its importance, and objectives, Quality management principles: continuous improvement, customer focus, and leadership, QualityManagement Systems (QMS), Quality Assurance vs. Quality Control	06
II	**Good Manufacturing Practices (GMP) in the Pharmaceutical Industry** GMP Regulations and Guidelines, Compliance with GMP requirements in pharmaceutical manufacturing, GMP Documentation and Record Keeping, Importance of GMP documentation and record-keeping, Application of statistical process control (SPC) in quality assurance.	06
III	**Quality Control Techniques and Methods** Overview of quality control in pharmaceutical manufacturing, Analytical methods for quality control: chromatography, spectroscopy, and titration, Application of statistical Process control (SPC) in quality assurance.	08
IV	**Quality Management Systems (QMS) in Pharmaceuticals** Implementation of QMS in pharmaceutical companies, SO standards in pharmaceutical quality management, Risk management principles and practices in QMS.	06
V	**Regulatory Requirements for Pharmaceutical Products** FDA Regulations and Compliance, International regulatory standards: EMA (European Medicines Agency), ICH (International Council for Harmonization), etc.	04
VI	**Case Studies on Quality Assurance and Regulatory Compliance Issues** Case Studies on Quality Control Failures, Overview of regulatory compliance challenges in the pharmaceutical industry, addressing compliance issues: inspections, audits, and corrective actions, Strategies for maintaining compliance with evolving regulatory requirements.	06
Text Books		
1.	Allen, L. V., & Popovich, N. G. (2016). Ansel's Pharmaceutical Dosage Forms and Drug Delivery Systems. Lippincott Williams & Wilkins.	
Reference Books		
1.	Lee, M. Y. (2018). Good Manufacturing Practice for Pharmaceuticals: A Plan for Total Quality Control from Manufacturer to Consumer. Wiley.	
2.	Nahata, M. C., & Hipple, T. F. (2018). Quality Assurance in Pharmacy Practice. CRC Press	

<table>
<tr><td>Year, Program, Semester</td><td colspan="7">Specialization Minor I, 4th Semester onwards</td></tr>
<tr><td>Course Code</td><td colspan="7">SPM-1.4</td></tr>
<tr><td>Course Category</td><td colspan="7">Program Based Internship</td></tr>
<tr><td>Course Title</td><td colspan="7">Pharmaceutical Industry Internship</td></tr>
<tr><td rowspan="2">Teaching Scheme and Credits</td><td>L</td><td>T</td><td>P</td><td colspan="2">Total Contact Hours</td><td colspan="2">Total Credits</td></tr>
<tr><td colspan="4">One Month</td><td colspan="2">03</td></tr>
<tr><td rowspan="2">Evaluation Scheme</td><td colspan="2">ISE</td><td>ESE</td><td>IOE</td><td>IPE</td><td>EOE</td><td>EPE</td><td>Total</td></tr>
<tr><td colspan="2">00</td><td>00</td><td>50</td><td>-</td><td>50</td><td>-</td><td>100</td></tr>
<tr><td>Pre-requisites(if any)</td><td colspan="7">Basics of unit processes and unit operations.</td></tr>
<tr><td>Course Rationale</td><td colspan="7">The Industrial Internship course caters specifically to B.Tech Chemical Engineering students pursuing additional specialization through the B.Tech Minor program in areas such as Pharmaceutical Technology This course offers practical exposure to industry settings aligned with their chosen sub-specialization, aiming to bridge the gap between theoretical knowledge and practical application. By engaging in a one-month internship, students gain firsthand experience, essential skills, and insights crucial for their future careers in specialized sectors of chemical engineering.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">The course teacher will
1. Help expose students to the 'real' working environment;
2. Promote hands-on experience to the students’ in their related field;
3. Develop synergetic collaboration between industry and the university in promoting a knowledgeable society;
4. Assist in providing the opportunity for students to test their interest in a particular career before permanent commitments are made.
5. Elaborate the dynamic and challenging nature of industrial environments</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">Upon completion of this course, student should be able to
1. Understand industrial processes and operations related to their minor sub-specializations.
2. Apply theoretical concepts to solve practical problems in the industry.
3. Communicate effectively with industry professionals, colleagues, and supervisors.
4. Collaborate efficiently in team environments to complete tasks and projects.
5. Adapt to the dynamic and challenging nature of industrial environments.
6. Reflect on internship experiences for personal and professional growth.</td></tr>
</table>

Course Outcome and Program Outcome Mapping

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	-	-	-	-	-	-	-	-	-	-	-
CO 2	-	3	2	-	-	-	-	-	-	-	-	-
CO 3	-	-	-	-	-	-	-	-	-	3	-	-
CO 4	-	-	-	-	-	-	-	-	3	-	-	-
CO 5	-	-	-	-	-	2	-	-	-	-	-	3
CO 6	-	-	-	-	-	-	-	-	-	-	-	2

Level of Mapping as: Low 1, Moderate 2, High 3

Course Content	Hours
The course consists of a one-month internship in a relevant specialized industry. Students will be placed in companies or organizations that align with their chosen sub-specialization within the field of chemical engineering. During the internship, students will engage in various activities, including but not limited to: 1. Shadowing industry professionals to observe and learn about different processes and operations. 2. Assisting with ongoing projects or research initiatives within the organization. 3. Participating in hands-on tasks related to their minor sub-specialization, under the guidance of experienced mentors. 4. Attending training sessions, workshops, and seminars conducted by the industry to enhance their knowledge and skills. 5. Engaging in discussions and meetings with supervisors and colleagues to gain insights into industry practices, challenges, and innovations. 6. Documenting their internship experience through reports, presentations, or reflective journals. The period of one month for this internship will be during the winter or summer vacations, any such slots 4th Semester onwards.	4 weeks

Course Evaluation Method

The evaluation for the Industrial Internship course will be conducted as follows:

- **Internal Evaluation (50 marks):**
    - Assessment by course teachers based on students' performance during the internship, including attendance, participation, attitude, and contribution to assigned tasks.

- Evaluation by industrial supervisors on students' professional conduct, technical skills, problem-solving abilities, and overall performance in the workplace.

- **External Evaluation (50 marks):**
  - Evaluation by an external examiner appointed by the institute, who will assess students' internship reports, presentations, or any other documentation submitted at the end of the internship period.
  - The external examiner will review the quality of students' reflections on their internship experience, their ability to apply theoretical knowledge to practical situations, and the depth of their understanding of industry practices and challenges.

The final grades for the Industrial Internship course will be determined based on the combined assessment from both internal and external evaluations.

Reference Books	
1.	Thakur, S. S., &Rathore, M. S. (2019). Pharmaceutical Engineering: Principles and Practices.
2.	Kokate, C., &Niazi, S. U. (2018). Introduction to Pharmaceutical Engineering.

Year, Program, Semester	Specialization Minor I, 4th Semester onwards										
Course Code	SPM 1.5										
Course Category	Project Based Learning										
Course Title	**Mini Project**										
Teaching Scheme and Credits	**L**	**T**	**P**	**Total Contact Hours**				**Total Credits**			
	-	-	-	-				02			
Evaluation Scheme	**ISE**	**ESE**		**IOE**	**IPE**			**EOE**	**EPE**	**Total**	
	00	00		50	-			50	-	100	
Pre-requisites(if any)	Basics of unit processes and unit operations.										
Course Rationale	This course aims to provide students with practical exposure and hands-on experience in real-world industrial settings, fostering a deeper understanding of theoretical concepts through application. By engaging in this mini project, students will develop essential skills such as problem-solving, teamwork, and communication, preparing them for future challenges in the professional arena in the Pharmaceutical Industry.										
Course Objectives	The course teacher will 1. Facilitate application of theoretical knowledge. 2. Guide the students about enhancement of practical skills. 3. Explain about development of industry-relevant competencies.										
Course Outcomes	Upon completion of this course, student should be able to 1. Demonstrate application of theoretical concepts with instructor guidance. 2. Collaborate effectively in instructor-led team-based projects. 3. Communicate findings and insights professionally under instructor supervision.										

Course Outcome and Program Outcome Mapping

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	2	-	-	2	-	-	-	2	-	-	-
CO 2	-	-	3	-	-	-	-	-	3	-	2	1
CO 3	-	-	-	-	-	-	-	-	-	3	-	2

Level of Mapping as: Low 1, Moderate 2, High 3

Course Content

Specialization Minor Program Based Mini Project is a dynamic course designed to bridge the gap between classroom learning and real-world application. All the students will engage themselves in a series of tasks and challenge that will enable them to apply theoretical concepts learned in previous courses to solve practical problems. The project work need to be carried out independently covering a range of topics relevant to their field of study, allowing them to explore different facets of the particular discipline and develop versatile skill sets.

This activity may be planned after 4th Semester and can be completed prior to 8th Semester of their Major studies.

Course Assessment Process

The course evaluation for the internals will be at the course teacher end while there will also be the external evaluation of the Project work.

The teachers will follow the instructions as below:

Evaluation Format: The evaluation may be conducted using a combination of assessment methods, including:

- Rubric-based assessment for the project work and its report.
- Peer evaluation for project.
- Instructor-led discussions or presentations to evaluate communication skills and critical thinking.
- Overall course grading based on a weighted average of individual assessments and participation.

The evaluation format should be transparent, fair, and aligned with the course objectives and outcomes. Regular feedback and communication with students will ensure that the evaluation process remains supportive of their learning journey.

Specialization Minor
In
Alcohol Technology
For
B.Tech(Chemical Engineering)

Shivaji University, Kolhapur

Department of Technology

Specialization Minor in Alcohol Technology

Teaching & Evaluation Scheme

Sr. No.	Category	Course Code	Course Title	Hours per week			Contact Hours	Credits	Evaluation Scheme	
									Theory	Practical
				L	T	P			ISE:ESE	IE:EE
1.	Preferably on SWAYAM (NPTEL) or any other MOOCs (Minor Program Core) Or In a Face-to-Face mode	SPM 2.1	Industrial Fermentation	03	-	-	03	03	30:70	00:00
2.		SPM 2.2	Alcohol Manufacturing	03	-	-	03	03	30:70	00:00
3.		SPM 2.3	Technology of Malting and Brewing	03	-	-	03	03	30:70	00:00
4.	Minor Program Based Internship	SPM 2.4	Alcohol Industry Internship	One Month				03	00:00	50:50
5.	Project Based Learning	SPM 2.5	Mini Project	-	-	-	-	02	-	50:50
				-	**-**	**-**	**-**	**14**	**300**	**200**
			Total Hours	**09**	**00**	**00**	**09**	**-**	**-**	**-**

Note: If opted the Specialization Minor Program, Internship may be planned during winter or summer vacation days after 4th semester while respective evaluations will appear on a separate mark sheet.

Specialization Minor II : Alcohol Technology

Year, Program,Semester	Specialization Minor II, 4th Semester onwards						
Course Code	SPM-2.1						
Course Category	Specialization Minor Program Core						
Course title	**Industrial Fermentation**						
Teaching Scheme andCredits	L	T	P	Total Contact Hours		Total Credits	
	03	-		03		03	
Evaluation Scheme	ISE	ESE	IOE	IPE	EOE	EPE	Total
	30	70	-	-	-	-	100
Pre-requisites(if any)	The pre-requisite for this course is understanding of mathematics, First year undergraduate level of (bio) chemistry and biology and overview of the fundamental courses of Chemical Engineering.						
Course Rationale	This course emphasizes the application of biological and engineering principles to problems involving microbial, mammalian, and biological/biochemical systems. The aim of the course is to review fundamentals and provide an up-to- date account of current knowledge in biological and biochemical technology. Industrial fermentation is a base of numerous industrial processes, ranging from the production of antibiotics and vaccines to the manufacture of biofuels and specialty chemicals. Understanding the principles and practices of fermentation is essential for students aspiring to work in these sectors.						
Course Objectives	The Course Teacher will 1. Explain the principles of industrial fermentation including microbial growth kinetics, substrate utilization, and product formation. 2. Describe knowledge of various types of fermentation processes used in industry, such as aerobic and anaerobic fermentation. 3. Illustrate about the different types of microorganisms involved in industrial fermentation and their characteristics. 4. Explore the various raw materials and media used in industrial fermentation and their impact on the fermentation process. 5. Enhance about downstream processing techniques for the purification and recovery of fermentation products. 6. Develop the importance of safety, quality control, and regulatory compliance in industrial fermentation operations.						

Course Outcomes	Upon completion of this course, student should be able to 1. Describe the fundamental principles underlying microbial growth and metabolism in industrial fermentation. 2. Differentiate between different types of fermentation processes and theirapplications in various industries. 3. Identify and characterize key microorganisms used in industrial fermentation and their respective roles. 4. Design fermentation media and optimize process parameters for specific fermentation applications. 5. Design and implement downstream processing strategies for the purification and recovery of fermentation products. 6. Evaluate the safety, quality, and regulatory aspects of industrial fermentation processes.

Course Outcome and Program Outcome Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO 12
CO 1	2	1	-	-	-	-	-	-	-	-	-	-
CO 2	3	2	1	-	-	-	-	-	-	-	-	-
CO 3	2	2	1	-	-	-	-	-	-	-	-	-
CO 4	2	2	3	1	1	1	1	-	2	-	-	-
CO 5	2	2	3	1	1	1	1	-	2	-	-	-
CO 6	2	-	2	-	-	2	2	-	-	-	1	-

Level of Mapping as: Low 1, Moderate 2, High 3

Unit No.	Course Content	Hours
I	**Introduction to fermentation** History and development fermentation, Definition and scope of industrial fermentation, Importance and applications in various industries	**06**
II	**Fermentation Process Fundamentals** Substrate selection and preparation, Sterilization techniques, Inoculum preparation, Fermentation kinetics and monitoring	**06**
III	**Microorganisms Used in Industrial Fermentation** Introduction to Microbial Growth Kinetics, Batch culture (Quantifying cell concentration, Growth patterns and Kinetics), Continuous culture, Comparison of batchand continuous cultures in industrial processes, Fed batch culture, Examples of use of fed batch cultures. Isolation, preservation and improvement of industrial microorganisms Isolation methods utilizing selection of the desired characteristics,	**07**

	Isolation methods not utilizing selection of the desired characteristics, The preservation of industrially important microorganisms, Improvement of industrial microorganisms	
IV	**Media for industrial fermentations & sterilization** Introduction, Typical media, Energy sources, Carbon sources, Nitrogen sources, Buffers, Oxygen requirements, Antifoams, Medium optimization, Medium sterilization: The design of batch sterilization processes, The design of continuous sterilization processes, Sterilization of the fermenter, feeds and air, Filter sterilization, The development of inocula for industrial fermentations, The development of inocula for yeast , bacterial and fungal processes, The aseptic inoculation of plant fermenters	**07**
V	**Various Industrial Fermentation Processes, Equipment and Facilities** Aerobic vs. anaerobic fermentation, Batch, fed-batch, and continuous fermentation, Solid-state fermentation Bioreactor design and operation, Aeration and agitation systems, Downstream processing equipment	**08**
VI	**Industrial Fermentation Applications** Food and beverage production, Pharmaceutical and biopharmaceutical manufacturing, Biofuel production, Enzyme production, Organic acid production, Industrial microbiology and biotechnology	**05**
	Text Books	
1.	James E. Bailey and David F. Ollis, (July 2017), Biochemical Engineering Fundamentals, (2nd edition), McGraw Hill Education.	
2.	Jurgen Krause and Oswald Fleischer, ((18 May 2010), Industrial Fermentation: Food Processes, Nutrient Sources & Production Strategies, Nova Science Publishers Inc.	
	Reference Books	
1.	E. M. T. El-Mansi, C. F. A. Bryce, B. Dahhou, and S. Sanchez,(January 2000), Fermentation Microbiology and Biotechnology, (3 rd edition), Taylor and Francis Books Limited U.K.	

<table>
<tr><td>Year, Program, Semester</td><td colspan="7">Specialization Minor II, 4th Semester onwards</td></tr>
<tr><td>Course Code</td><td colspan="7">SPM-2.2</td></tr>
<tr><td>Course Category</td><td colspan="7">Specialization Minor Program Core</td></tr>
<tr><td>Course Title</td><td colspan="7">Alcohol Manufacturing</td></tr>
<tr><td rowspan="2">Teaching Scheme andCredits</td><td>L</td><td>T</td><td>P</td><td colspan="2">Total Contact Hours</td><td colspan="2">Total Credits</td></tr>
<tr><td>03</td><td>-</td><td></td><td colspan="2">03</td><td colspan="2">03</td></tr>
<tr><td rowspan="2">Evaluation Scheme</td><td colspan="2">ISE</td><td>ESE</td><td>IOE</td><td>IPE</td><td>EOE</td><td>EPE</td><td>Total</td></tr>
<tr><td colspan="2">30</td><td>70</td><td>-</td><td>-</td><td>-</td><td>-</td><td>100</td></tr>
<tr><td>Pre-requisites(if any)</td><td colspan="7">The pre-requisite for this course is understanding of mathematics, First year undergraduate level of (bio) chemistry and biology and overview of the fundamental courses of Chemical Engineering</td></tr>
<tr><td>Course Rationale</td><td colspan="7">Alcohol manufacturing involves a variety of industrial processes and technologies, including fermentation, distillation, filtration, and aging. Teaching students about these processes equips them with practical knowledge applicable to various industries, such as brewing, distilling, and winemaking.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">The Course Teacher will
1. Understand the fundamental principles and processes involved inalcohol manufacturing, including fermentation, distillation, and purification techniques.
2. Explore the various types of raw materials used in alcohol production, such as grains, fruits, and sugars, and their impact on the final product.
3. Examine the role of microorganisms, enzymes, and other catalysts inthe fermentation process and their optimization for efficient alcohol production.
4. Learn about the equipment, instrumentation, and technologies utilizedin alcohol manufacturing facilities.
5. Understand the regulatory requirements, safety protocols, and environmental considerations associated with alcohol production.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">Upon completion of this course, student should be able to
1. Demonstrate a comprehensive understanding of the principles and processes involved in alcohol manufacturing.
2. Identify and evaluate the suitability of different raw materials foralcohol production based on their chemical composition and availability.
3. Apply microbial and enzymatic techniques to optimize fermentation processes for alcohol production.
4. Operate and maintain equipment used in various stages of alcohol manufacturing, including fermentation tanks, stills, and purification systems.
5. Interpret and comply with regulatory requirements and safetystandards relevant to alcohol production facilities.</td></tr>
</table>

Course Outcome and Program Outcome Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO 12
CO 1	2	1	-	-	-	-	-	-	-	-	-	-
CO 2	3	2	-	-	-	-	-	-	-	-	-	-
CO 3	2	2	2	1	-	-	-	-	-	-	-	-
CO 4	2	2	3	1	-	-	-	-	-	-	-	-
CO 5	2	2	2	1	1	-	-	-	-	-	-	-

Level of Mapping as: Low 1, Moderate 2, High 3

Unit No.	Course Content	Hours
I	**Introduction to Alcohol Manufacturing** Introduction to Alcohol Technology, Raw Material of Alcohol Industry, Storage & handling of raw material.	06
II	**Raw Materials** Study of different yeast strains used in alcohol industries, Study of yeast production as single protein cell, Wet milling of grain for alcohol production, Grain dry milling cooking for alcohol production, Use of cellulosic feed stocks for alcohol production.	06
III	**Fermentation** Study of different alcoholic fermentation techniques, Biochemical processes in fermentation, Batch fermentation, Continuous fermentation, Modem techniques of Continuous fermentation, Bio still fermentation, Fermentation vessel design and operation, By product of alcoholic fermentation.	07
IV	**Distillation** Principles of distillation, Batch and continuous distillation techniques Distillation equipment and operation, Steps for optimizing Performance of Distillation Columns, Effective utilization of column heat. Pinch Technology. Principles of distillation.	07

Text Books	
1.	T.P. Lyons, K.A. Jacques, D.R Kensal, (November 1999), The Alcohol Textbook: A Reference for the Beverage, Fuel and Industrial Alcohol Industries, (3rd edition), Nottingham University Press
2.	T.P. Lyons (Editor), D.R Kelsall (Editor), J.E. Murtagh (Editor), (1 October 1995), The Alcohol Textbook: Ethanol Production by Fermentation and Distillation, Nottingham University Press
Reference Books	
1.	Johann G. Stichlmair, James R. Fair, (29 September 1998), Distillation: Principles and Practices,(1st edition), Wiley-VCH.

<table>
<tr><td>Year, Program, Semester</td><td colspan="7">Specialization Minor II, 4th Semesters onwards</td></tr>
<tr><td>Course Code</td><td colspan="7">SPM-2.3</td></tr>
<tr><td>Course Category</td><td colspan="7">Specialization Minor Program Core</td></tr>
<tr><td>Course Title</td><td colspan="7">Technology of Malting & Brewing</td></tr>
<tr><td rowspan="2">Teaching Scheme and Credits</td><td>L</td><td>T</td><td>P</td><td colspan="2">Total Contact Hours</td><td colspan="2">Total Credits</td></tr>
<tr><td>03</td><td>-</td><td></td><td colspan="2">03</td><td colspan="2">03</td></tr>
<tr><td rowspan="2">Evaluation Scheme</td><td colspan="2">ISE</td><td>ESE</td><td>IOE</td><td>IPE</td><td>EOE</td><td>EPE</td><td>Total</td></tr>
<tr><td colspan="2">30</td><td>70</td><td>-</td><td>-</td><td>-</td><td>-</td><td>100</td></tr>
<tr><td>Pre-requisites(if any)</td><td colspan="7">The pre-requisite for this course is understanding of mathematics, First year undergraduate level of (bio) chemistry and biology and overview of the fundamental courses of Chemical Engineering.</td></tr>
<tr><td>Course Rationale</td><td colspan="7">This course provides students with a comprehensive understanding of the scientific, technical, and practical aspects of beer production. Understanding the technology behind malting and brewing is crucial for students aspiring to work in this industry.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">The Course Teacher will
1. Discuss the fundamental principles and processes involved in maltingand brewing.
2. Explore the anatomy and biochemistry of grains used in malting and brewing, with a focus on barley.
3. Explain the malting process, including steeping, germination, and kilning, and its impact on grain modification and enzyme development.
4. Illustrate about the role of enzymes, particularly amylases and proteases, in the malting and mashing processes.
5. Enlist brewing techniques, including mashing, lautering, boiling, fermentation, and conditioning, and their effects on flavor, aroma, and alcohol content.
6. Describe the microbiology of brewing, including the role of yeast and other microorganisms in fermentation and the prevention of spoilage.</td></tr>
</table>

Course Outcomes	Upon completion of this course, student should be able to 1. Demonstrate a comprehensive understanding of the malting and brewing processes, including their chemical and biochemical principles. 2. Identify and evaluate different types of grains suitable for maltingand brewing based on their characteristics and quality parameters. 3. Apply malting techniques to produce malt with desired attributes for brewing purposes. 4. Utilize brewing equipment and techniques to produce various styles of beer while controlling factors such as color, flavor, and alcohol content. 5. Analyze and interpret data from laboratory tests and sensory evaluations to assess the quality of malt and beer. 6. Acquire proficiency in troubleshooting common issues encountered during the malting and brewing processes

Course Outcome and Program Outcome Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO 12
CO 1	2	1	-	-	-	-	-	-	-	-	-	-
CO 2	3	2	-	-	-	-	-	-	-	-	-	-
CO 3	2	2	2	1	-	-	-	-	-	-	-	-
CO 4	2	2	3	1	-	-	-	-	-	-	-	-
CO 5	2	2	2	1	1	-	-	-	-	-	-	-
CO 6	2	2	2	2	-	-	-	-	-	-	-	-

Level of Mapping as: Low 1, Moderate 2, High 3

Unit No.	Course Content	Hours
I	**Introduction to Malting and Brewing** Introduction of brewing, history of brewing; Raw materials: barley, hops, water, yeast; Adjuncts for beer production: Maize, rice, millet, wheat, sugar etc	06
II	**Malting Process** Malt production, role of enzymes for malting; Barley storage, steeping, germination, kilning, cooling, storage; Malt from other cereals, caramel malt, roasted malt, smoked malt, malt extract; Malt quality evaluation, Wort production, malt milling, Mashing, Mashing vessels; Wort boiling, clarification, cooling and aeration	09
III	**Brewing Process Overview** Beer production methods, fermentation technology, changes during fermentation; Filtration procedure and equipment, beer stabilization conditions and durations, beer carbonation process	07
IV	**Yeast and Brewing Equipment** Types of brewing yeast, Yeast propagation and handling, Fermentation kinetics, Brewhouse equipment and layout, Fermentation vessels, Packaging equipment.	06

V	**Brewing Techniques and Styles** Ale brewing, Lager brewing, Specialty beer styles, Craft brewing techniques, Sustainable sourcing of ingredients.	**06**
VI	**Emerging Trends in Malting and Brewing,** Novel ingredients and flavors, Brewing with alternative grains, Non-alcoholic brewing	**05**
	Textbooks	
1.	Kunze Wolfgang, (January 1, 2014), Technology Brewing and Maltin, (5th edition), VLB Berlin.	
2.	J. S. Hough, D. E. Briggs , R. Stevens , T. W. Young ,(1 March 2013), Malting and Brewing Science: Volume II Hopped Wort and Beer, (1st ed. 1982 edition) Springer-Verlag New York Inc. Softcover reprint of the original.	
	Reference books	
1.	D.E. Briggs, R. Stevens, Tom W. Young, J.S. Hough, ((December 1, 1981), Malting and Brewing Science, Volume 1: Malt and Sweet Wort, (2nd edition), Springer.	

<table>
<tr><td>Year, Program, Semester</td><td colspan="7">Specialization Minor II, 4th Semester onwards</td></tr>
<tr><td>Course Code</td><td colspan="7">SPM-2.4</td></tr>
<tr><td>Course Category</td><td colspan="7">Program Based Internship</td></tr>
<tr><td>Course Title</td><td colspan="7">Alcohol Industry Internship</td></tr>
<tr><td rowspan="2">Teaching Scheme and Credits</td><td>L</td><td>T</td><td>P</td><td colspan="2">Total Contact Hours</td><td colspan="2">Total Credits</td></tr>
<tr><td colspan="4">One Month</td><td colspan="2">03</td></tr>
<tr><td rowspan="2">Evaluation Scheme</td><td colspan="2">ISE</td><td>ESE</td><td>IOE</td><td>IPE</td><td>EOE</td><td>EPE</td><td>Total</td></tr>
<tr><td colspan="2">00</td><td>00</td><td>50</td><td>-</td><td>50</td><td>-</td><td>100</td></tr>
<tr><td>Pre-requisites(if any)</td><td colspan="7">Basics of unit processes and unit operations</td></tr>
<tr><td>Course Rationale</td><td colspan="7">The Industrial Internship course caters specifically to B.Tech Chemical Engineering students pursuing additional specialization through the B.Tech Minor program in areas such as Alcohol Technology This course offers practical exposure to industry settings aligned with their chosen sub-specialization, aiming to bridge the gap between theoretical knowledge and practical application. By engaging in a one-month internship, students gain firsthand experience, essential skills, and insights crucial for their future careers in specialized sectors of chemical engineering.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">The course teacher will
1. Help expose students to the 'real' working environment.
2. Promote hands-on experience to the students’ in their related field.
3. Develop synergetic collaboration between industry and the university in promoting a knowledgeable society.
4. Assist in providing the opportunity for students to test their interest in a particular career before permanent commitments are made.
5. Elaborate the dynamic and challenging nature of industrial environments.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">Upon completion of this course, student should be able to
1. Understand industrial processes and operations related to their minor sub-specializations.
2. Apply theoretical concepts to solve practical problems in the industry.
3. Communicate effectively with industry professionals, colleagues, and supervisors.
4. Collaborate efficiently in team environments to complete tasks and projects.
5. Adapt to the dynamic and challenging nature of industrial environments.
6. Reflect on internship experiences for personal and professional growth.</td></tr>
</table>

Course Outcome and Program Outcome Mapping

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	-	-	-	-	-	-	-	-	-	-	-

CO 2	-	3	2	-	-	-	-	-	-	-	-	-
CO 3	-	-	-	-	-	-	-	-	-	3	-	-
CO4	-	-	-	-	-	-	-	-	3	-	-	-
CO5	-	-	-	-	-	2	-	-	-	-	-	3
CO6	-	-	-	-	-	-	-	-	-	-	-	2

Level of Mapping as: Low 1, Moderate 2, High 3

Course Content	Hours
The course consists of a one-month internship in a relevant specialized industry. Students will be placed in companies or organizations that align with their chosen sub-specialization within the field of chemical engineering. During the internship, students will engage in various activities, including but not limited to: 1. Shadowing industry professionals to observe and learn about different processes and operations. 2. Assisting with ongoing projects or research initiatives within the organization. 3. Participating in hands-on tasks related to their minor sub-specialization, under the guidance of experienced mentors. 4. Attending training sessions, workshops, and seminars conducted by the industry to enhance their knowledge and skills. 5. Engaging in discussions and meetings with supervisors and colleagues to gain insights into industry practices, challenges, and innovations. 6. Documenting their internship experience through reports, presentations, or reflective journals. The period of one month for this internship will be during the winter or summer vacations, any such slots 4th Semester onwards.	4 weeks

Course Evaluation Method

The evaluation for the Industrial Internship course will be conducted as follows:

- **Internal Evaluation (50 marks):**
    - Assessment by course teachers based on students' performance during the internship, including attendance, participation, attitude, and contribution to assigned tasks.

- Evaluation by industrial supervisors on students' professional conduct, technical skills, problem-solving abilities, and overall performance in the workplace.

- **External Evaluation (50 marks):**
  - Evaluation by an external examiner appointed by the institute, who will assess students' internship reports, presentations, or any other documentation submitted at the end of the internship period.
  - The external examiner will review the quality of students' reflections on their internship experience, their ability to apply theoretical knowledge to practical situations, and the depth of their understanding of industry practices and challenges.

The final grades for the Industrial Internship course will be determined based on the combined assessment from both internal and external evaluations.

Reference Books	
1.	Van der Woude, J. P. (Ed.). (2018). Alcohol Textbook: A Reference for the Beverage, Fuel and Industrial Alcohol Industries.
2.	Blume, D. (2007). Alcohol Can Be a Gas!:Fueling an Ethanol Revolution for the 21st Century.

Year, Program, Semester	Specialization Minor II, 4th Semester onwards							
Course Code	SPM 2.5							
Course Category	Project Based Learning							
Course Title	**Mini Project**							
Teaching Scheme and Credits	**L**	**T**	**P**	**Total Contact Hours**		**Total Credits**		
	-	-	-	-		02		
Evaluation Scheme	**ISE**	**ESE**		**IOE**	**IPE**	**EOE**	**EPE**	**Total**
	00	00		50	-	50	-	100
Pre-requisites(if any)	Basics of unit processes and unit operations.							
Course Rationale	This course aims to provide students with practical exposure and hands-on experience in real-world industrial settings, fostering a deeper understanding of theoretical concepts through application. By engaging in this mini project, students will develop essential skills such as problem-solving, teamwork, and communication, preparing them for future challenges in the professional arena in the Alcohol Industry.							
Course Objectives	The course teacher will 1. Facilitate application of theoretical knowledge. 2. Guide the students about enhancement of practical skills. 3. Explain about development of industry-relevant competencies.							
Course Outcomes	Upon completion of this course, student should be able to 1. Demonstrate application of theoretical concepts with instructor guidance. 2. Collaborate effectively in instructor-led team-based projects. 3. Communicate findings and insights professionally under instructor supervision.							

Course Outcome and Program Outcome Mapping

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	2	-	-	2	-	-	-	2	-	-	-
CO 2	-	-	3	-	-	-	-	-	3	-	2	1
CO 3	-	-	-	-	-	-	-	-	-	3	-	2

Level of Mapping as: Low 1, Moderate 2, High 3

Course Content

Specialization Minor Program Based Mini Project is a dynamic course designed to bridge the gap between classroom learning and real-world application. All the students will engage themselves in a series of tasks and challenge that will enable them to apply theoretical concepts learned in previous courses to solve practical problems. The project work need to be carried out independently covering a range of topics relevant to their field of study, allowing them to explore different facets of the particular discipline and develop versatile skill sets.

This activity may be planned after 4th Semester and can be completed prior to 8th Semester of their Major studies.

Course Assessment Process

The course evaluation for the internals will be at the course teacher end while there will also be the external evaluation of the Project work.

The teachers will follow the instructions as below:

Evaluation Format: The evaluation may be conducted using a combination of assessment methods, including:

- Rubric-based assessment for the project work and its report.
- Peer evaluation for project.
- Instructor-led discussions or presentations to evaluate communication skills and critical thinking.
- Overall course grading based on a weighted average of individual assessments and participation.

The evaluation format should be transparent, fair, and aligned with the course objectives and outcomes. Regular feedback and communication with students will ensure that the evaluation process remains supportive of their learning journey.

Specialization Minor
In
Oil and Paint Technology
For
B.Tech (Chemical Engineering)

Shivaji University, Kolhapur
Department of Technology

Specialization Minor in Oil and Paint Technology

Teaching & Evaluation Scheme

Sr. No.	Category	Course Code	Course Title	Hours per week			Contact Hours	Credits	Evaluation Scheme	
									Theory	Practical
				L	T	P			ISE:ESE	IE:EE
1.	Preferably on SWAYAM (NPTEL) or any other MOOCs (Minor Program Core) Or In a Face-to-Face mode	SPM 3.1	Introduction to Surface Coatings andtheir components	03	-	-	03	03	30:70	00:00
2.		SPM 3.2	Technology of Fats and Fat BasedProducts	03	-	-	03	03	30:70	00:00
3.		SPM 3.3	Technology of Formulation and Manufacture of Coatings	03	-	-	03	03	30:70	00:00
4.	Program Based Internship	SPM 3.4	Oil & Paint Industry Internship	One Month				03	-	50:50
5.	Project Based Learning	SPM 3.5	Mini Project	-	-	-	-	02	-	50:50
				-	-	-	-	14	300	200
			Total Hours	**09**	**00**	**00**	**09**	-	-	-

Note: If opted the Specialization Minor Program, Internship and Mini Project may be planned during winter or summer vacation days after 4th semester while respective evaluations will appear on a separate mark sheet.

Specialization Minor III: Oil and Paint Technology

Year, Program, Semester	Specialization Minor III, 4th Semester Onwards								
Course Code	SPM-3.1								
Course Category	Specialization Minor Program Core								
Course Title	**Introduction to Surface Coatings and their components**								
Teaching Scheme and Credits	L	T	P	Total Contact Hours			Total Credits		
	03	-	-	03			03		
Evaluation Scheme	ISE		ESE	IOE	IPE		EOE	EPE	Total
	30		70	-	-		-	-	100
Pre-requisites(if any)	Basics of unit processes and unit operations.								
Course Rationale	This course introduces basic concepts of surface coating, various oils, volatile components and other useful components. It's provides a lot of information of physical and chemical properties of useful components of paints.								
Course Objectives	The Course Teacher will 1. Discuss the composition of paints and its classifications. 2. Describe the chemical modifications of fixed oils to enhance their properties. 3. Describe the chemical modification of triglyceride oils. 4. Illustrate the mechanism, evaluation and combination of driers. 5. Discuss the various volatile solvents and their properties.								
Course Outcomes	Upon completion of this course, student should be able to 1. Aware about the composition and functions of Paints & Coatings. 2. Compare the composition and properties of various vegetable oils. 3. Understand the deficiencies of vegetable oils and to apply to improvethem upon, by chemical modifications. 4. Relate the mechanism of various driers and apply in coatings. 5. Interpret the composition and properties of various volatile solvents, anddesign thinners having the targeted properties.								

Course Outcome and Program Outcome Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO 12
CO 1	3	1	1	-	-	-	2	-	-	-	-	1
CO 2	3	2	2	-	-	-	1	-	-	-	-	1
CO 3	3	2	1	-	-	2	1	-	-	-	-	-
CO 4	3	2	2	-	-	2	-	-	-	-	-	1
CO 5	3	2	2	-	-	-	1	-	-	-	-	-

Level of Mapping as: Low 1, Moderate 2, High 3

Unit No.	Course Content	Hours
I	**Surface Coatings** Definitions and general classifications; paints, varnishes and lacquers; their components and functions; coating binders, media/vehicles, pigmentations, paint manufacture; dispersion, soaking, flocculation, emulsion, stabilization, coating applications; mechanism of film formation; modern surface coatings; properties of surface coatings and their films; film ageing; Indian and global picture of paint industry; career in paint Technology.	07
II	**Fixed Oils** Essential, mineral and fixed oils; sources and composition of glyceride oils; molecular structure of tri-glyceride oils; non-glyceride components of oils; constitution and molecular structure of fatty acids; distribution of fatty acids in oil molecules; extraction of oils; processing of oils; evaluation & characterization of oils – physical and chemical; fatty acid composition and characteristics of individual oils; classification of glyceride oils-drying, semi drying and non-drying oils; properties and uses of glyceride oils; yellowing and non-yellowing oils; chemical properties of oils – oxidation, iodination and hydrogenation, hydrolysis, acidolysis, alcoholysis, saponification, sulphation, sulphonation, epoxidation; fatty alcohols and fatty amines; foreign matter, breaks and foots in oils.	07
III	**Modifications of Oils** Deficiencies in oil films; chemical modifications of triglyceride oils- heat bodied/thermally polymerized (stand) oils, blown oils, boiled & double boiled oils; solvent segregation; isomerized oils; dehydrated castor oils; maleinized oils & water soluble oils; co-polymerized oils; reconstituted (semi-synthetic) oils; limed oils; catalyzed oils; methyl esters and biodiesel, refining of oils, contamination: sources, causes and effects.	08
IV	**Coating Driers** Constitution; active & auxiliary, primary and secondary; surface & through driers; metal part and organic acid part of driers; properties and uses of individual driers; mechanism of drier action; manufacture of driers; evaluation of driers; combination of driers; drier dosage; drier substitutes; drier related paint film defects; driers for water based coatings; future trends.	07
V	**Volatile Solvents and Other Components** General classes of solvents, properties of solvents e.g. solvent (cutting) power, rate of evaporation, boiling point &vapor pressure, distillation range, flash point, auto ignition temperature, toxicity, aromatic content etc.; chromatographic techniques for solvent analysis; criteria of solubility; thermodynamics of solubility; solubility parameters; solvent mixture (thinners)–true solvents, latent solvents and diluents; evaporation properties of solvent mixtures; azeotropes; activity coefficients; evaporation from polymer films; sources and properties of individual solvents. Water as coating solvent; effect of volatile solvents on film properties; use of supercritical fluids as solvents; uses of solvents with different binder systems; safety, health & environmental aspects	07
Text Books		
1.	Oil and Colour Chemists' Association. (1993). Surface Coatings: Raw Materials and their Usage (Vol. I). (3rd ed.). Springer Science &Business Media, Australia.	
2.	Morgans, W. M. (1969). Outlines of Paint Technology. Griffin.	
3.	Solomon, D. H. (1977). The chemistry of organic film formers (2nd ed.).Malabar, Fla. : R. E. Krieger Pub. Co.	
4.	Sikchi, M. A., & Malshe, V.C. (2004).Basics of Paint Technology- Part 1.Antar Prakash Centre forYoga.	

5.	Malshe, V.C., & Sikchi, M. A. (2008). Basics of Paint Technology-Part 2. Antar Prakash Centre for Yoga.
6.	Paul, S. (1995). Surface Coatings: Science and Technology (2nd ed.). John Wiley and Sons.
Reference Books	
1.	Payne, H.F. (1961). Organic Coating Technology - Volume 2: Pigments and Pigmented Coatings.John Wiley & Sons, New York.
2.	Payne, H. F. (1954). Organic Coating Technology-Volume 1: Oils, Resins, Varnishes and Polymers. New York, NY, John Wiley & Sons.
3.	Georgalas, N. (1980). Introduction to paint chemistry (2nd ed.). G. P. A. Turner, Chapman and Hall, New York.
4.	LamBournee, R., &Striven, T.A. (1999). Paint and surface coating theory and practice (2nded.). Woodhead Publishing.
5.	Wicks, Z.W., Jones, F.N., & Pappas, S.P. (2007). Organic Coatings: Science and Technology. Wiley Interscience.
6.	Matellio, J. J. (1941). Protective and Decorative Coatings: Paints, Varnishes, Lacquers, and Inks. (Vol. 1). John Wiley and Sons, New York.

Year, Program, Semester	Specialization Minor III, 4th Semester onwards						
Course Code	SPM-3.2						
Course Category	Specialization Minor Program Core						
Course Title	**Technology of Fats and Fat Based Products**						
Teaching Scheme andCredits	L	T	P	Total Contact Hours		Total Credits	
	03	-		03		03	
Evaluation Scheme	ISE	ESE	IOE	IPE	EOE	EPE	Total
	30	70	-	-	-	-	100
Pre-requisites(if any)	Knowledge of basic sciences organic chemistry.						
Course Rationale	The course provides necessary knowledge of demand and supply scenario of Fat & oils its storage and handling, physical and chemical properties as well as fatty acid composition. Course also provide knowledge of natural and Processing of Fats and Fat Base product.						
Course Objectives	The Course Teacher will 1. Describe the sources of fats and oils. 2. Elaborate Physiochemical properties of fats and oils. 3. Discuss the utilization and classification of fats and oils. 4. Illustrate the handling and storage of oil bearing materials. 5. Explain the processing of Oil and fats. 6. Enlist uses of fats and oils.						
Course Outcomes	Upon completion of this course, student should be able to 1. Understand various essential oils, their sources & grades. 2. Characterize various essential oils in various applications as per their physico- chemical properties. 3. Isolate various active components of essential oils and their recoveryby different suitable process. 4. Develop various fat and oil modification. 5. Outline the processing of oils and fats. 6. Describe uses of fats and oils.						

Course Outcome and Program Outcome Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO 12
CO 1	3	2	1	-	-	1	-	-	-	-	-	-
CO 2	3	2	1	-	-	1	-	-	-	-	-	-
CO 3	3	2	-	-	-	1	-	-	-	-	-	-
CO 4	3	2	1	1	-	1	-	-	-	-	-	-
CO 5	3	2	1	1	-	1	-	-	-	-	-	-
CO 6	3	2	1	1	-	1	-	-	-	-	-	-

Level of Mapping as: Low 1, Moderate 2, High 3

Unit No.	Course Content	Hours
I	**Introduction** Sources of fats and oils; Handling of oil bearing materials; Processing of soil sulphates; Food uses: Soaps and detergents; Paints and Polishes	06
II	**Physico-chemical Properties of Fats and Oils** Hydrolysis, esterification and related reactions; Other reactions involving carboxyl groups; Reactions in the fatty acid chain; Oiliness and viscosity; Physical thermal and electrical properties; Smoke, fire and flash point; Solubility, miscibility, emulsions and emulsifiers: Optical properties.	09
III	**Sources, Utilization and Classification of Fats and Oils** Sources of commercial fats and oils; Utilization of commercial fats and oils; Classification of fats and oils; Non-conventional sources of edible and commercial oil: Composition and characteristics of major fats and oils.	07
IV	**Handling, Storage and Grading of Oils and Oil Bearing Materials** Deterioration in crude oil and oil bearing materials; Grading and evaluation: Handling and storage. Processing of Oil Bearing Material Rendering and trying out; Mechanical Expression; Hydraulic pressing and expressing: Solvent extraction**.**	06
V	**Processing of Oils and Fats** Physical and chemical refining; Hydrogenation process, plant and quality control in hydrogenation; Fractionation of oils and fats; Inter esterification. Food Use of Fats and Oils Shortenings; Salad oils; Margarine; Use of confectionery products; Packaging and storage of oils and fat based foods; Standards and quality control. Soaps and Detergents.	06
VI	**Food Use of Fats and Oils** Shortenings; Salad oils; Margarine; Use of confectionery products; Packaging and storage of oils and fat based foods; Standards and quality control.	05
	Text Books	
1.	Hamilton, R.J. and Bhati, A. "Fats and Oils Chemistry and Technology". Applied Science Publishers Ltd., 1980.	
2.	Williams, K.A. "Oils, Fats and Fatty Foods". J. and A. Churchil Ltd. London. 1986. Weiss, T.J., "Foods, Oils and Other Uses". AVI Publishing Co., 1970.	
3.	Bailey's Industrial Oil and Fat Products Volume I to V by Daniel Swern, A Wiley Interscience Publication (1979)	
	Reference Books	
1.	Gillies .M.T. "Shortenings, Margarine and Food Oils". Noyes Data Corporation,1974.	
2.	Desrosiar, N.W. "Elements of Food Technology", AVI Publishing Co., 1977	
3.	Palm oil by F. D. Gunstone, John Wiley and Sons (1987)	
4.	Oils and Fats Manual (Vol. I & II) by A. Karleskind and J. P. Wolff, Lavoisier Publishing (996)	

<table>
<tr><td>Year, Program, Semester</td><td colspan="7">Specialization Minor III, 4th Semester onwards</td></tr>
<tr><td>Course Code</td><td colspan="7">SPM-3.3</td></tr>
<tr><td>Course Category</td><td colspan="7">Specialization Minor Program Core</td></tr>
<tr><td>Course Title</td><td colspan="7">Technology of Formulation and Manufacture of Coatings</td></tr>
<tr><td rowspan="2">Teaching Scheme and Credits</td><td>L</td><td>T</td><td>P</td><td colspan="2">Total Contact Hours</td><td colspan="2">Total Credits</td></tr>
<tr><td>03</td><td>-</td><td></td><td colspan="2">03</td><td colspan="2">03</td></tr>
<tr><td rowspan="2">Evaluation Scheme</td><td>ISE</td><td>ESE</td><td>IOE</td><td>IPE</td><td>EOE</td><td>EPE</td><td>Total</td></tr>
<tr><td>30</td><td>70</td><td>-</td><td>-</td><td>-</td><td>-</td><td>100</td></tr>
<tr><td>Pre-requisites(if any)</td><td colspan="7">Basics of unit processes and unit operations.</td></tr>
<tr><td>Course Rationale</td><td colspan="7">This course aims to introduce basic concepts of coating additives. It covers principles of coating formulation and manufacture. Course is emphasize the details of various main mixtures and mills used in paint industry.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">The Course Teacher will
1. Describe the role and dosage of additives and principles of coating formulation.
2. Illustrate the principles of coating manufacture.
3. Discuss the various equipment use in paint industry.
4. Explain the production planning, safety and health hazards, relatedto paint manufacture.
5. Discuss the modeling use for formulation of paint resin.
6. Describe the various useful laboratory experiments for paint.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">Upon completion of this course, student should be able to
1. Recognize various additives and their application in surfacecoatings. Formulate coatings for various application
2. Understand the principles of coating manufacture and their applications
3. Aware various equipment and machinery used in paint manufacture, their selection, calculations involved in efficient operation, economic considerations, etc.
4. Acquire the knowledge of production planning and factory layout. Safety, health and environment.
5. Utilize the knowledge of computer software for formulation ofresins and paints.
6. Apply knowledge of laboratorial experiments for formulating and preparing different types of paints.</td></tr>
</table>

Course Outcome and Program Outcome Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO 12
CO 1	3	2	1	-	-	-	1	-	-	-	-	1
CO 2	3	2	1	-	-	-	-	-	-	-	-	1
CO 3	3	2	1	-	-	-	1	-	-	-	-	1
CO 4	3	2	1	-	-	1	3	-	-	-	-	1

CO 5	3	2	1	-	2	1	-	-	-	-	-	1
CO 6	3	1	2	-	-	1	-	-	-	-	-	1

Level of Mapping as: Low 1, Moderate 2, High 3

Unit No.	Course Content	Hours
I	**Coating Additives and Principles of Coating Formulation** Coating Additives: Definition, nomenclature, role, scope of incorporation, dosage, side/adverse effects of use of additives (i) For solvent thinned paints: Wetting and dispersing agents, anti-settling, anti-sag, bodying agents/ thickener (ii) For water- thinned /latex (emulsion) paints: surface active agents (dispersing agents and stabilizers), anti-foam agents/defoamers, protective colloids and thickeners, Biocides (in-can and dry-film) preservatives, Algecides	**06**
II	**Principles of Coating Manufacture** Steps in Paint manufacturing, Phenomenon of Mixing, Soaking, wetting, grinding, dispersion and stabilization. Dispersion processes, Daniel wet and flow point, Composition of grinding vehicle, Classification of grinding equipment, important considerations in pigment dispersion and stabilization. Dispersion for aqueous media, high solids coatings.	**06**
III	**Equipment used:** Heavy duty mixtures, double blade mixers, sigma mixture, Warner &P'flauder sigma kneaders, pug mills, edge runner roller mills, Hammer mills, jet mills, Rotostator.Roll mills: Two roll mills, Triple roll mills; Vertical and horizontal construction etc.	**06**
IV	**Production planning, Factory Layout and Safety, Health & Environment:** Environment, Safety and Human Health Act (ESHA), Human resource Planning: Importance and processes, Job analysis and Engagements, Training need analysis and Training of staff, Factory lay out, Instrumentation and automation. Safety considerations in storage of hazardous and inflammable raw materials.	**06**
V	**Computers and modeling in paint resin formulating** Introduction to Computer Modeling: Basics of computer-aided design (CAD) and modeling software for paint resin formulation, Molecular Modeling Techniques & Application of Modeling in Paint Resin Formulating: Predicting properties such as Viscosity, adhesion, and durability, and optimizing formulations for desired performance characteristics.	**06**
VI	**Laboratory Experiments** Preparation of a sample of Dry distemper, Cement Paint, Oxide floor colour. Skim coat (Wall Putty), White Primer (Solvent base), Red oxide Primer, Synthetic Enamel, Air drying cum stoving Enamel, Road Marking Paint, Zinc Rich Primer, N.C. Lacquer, chlorinated rubber paint, Oil bound distempers.	**06**
Text Books		
1.	Oil and Colour Chemists' Association. (1993). Surface Coatings: Raw Materials and Their Usage (Vol. I). (3rd ed.). Springer Science & Business Media, Australia.	
2.	Morgans, W. M. (1969). Outlines of Paint Technology. Griffin.	
3.	Solomon, D. H. (1977). The chemistry of organic film formers (2nd ed.). Malabar, Fla.: R. E. Krieger Pub. Co.	
4.	Sikchi, M. A., &Malshe, V.C. (2004). Basics of Paint Technology- Part 1. Antar Prakash Centre for Yoga.	

5.	Malshe, V.C., &Sikchi, M. A. (2008). Basics of Paint Technology-Part 2. Antar Prakash Centre for Yoga.
Reference Books	
1.	Payne, H.F. (1961). Organic Coating Technology - Volume 2: Pigments and Pigmented Coatings. John Wiley & Sons, New York.
2.	Payne, H. F. (1954). Organic Coating Technology-Volume 1: Oils, Resins, Varnishes and Polymers. New York, NY, John Wiley & Sons.
3.	Georgalas, N. (1980). Introduction to paint chemistry (2nd ed.). G. P. A. Turner, Chapman and Hall, New York.
4.	LamBournee, R., & Striven, T.A. (1999). Paint and surface coating theory and practice (2nd ed.). Woodhead Publishing.

<table>
<tr><td>Year, Program, Semester</td><td colspan="7">Specialization Minor III, 4th Semester onwards</td></tr>
<tr><td>Course Code</td><td colspan="7">SPM-3.4</td></tr>
<tr><td>Course Category</td><td colspan="7">Program Based Internship</td></tr>
<tr><td>Course Title</td><td colspan="7">Oil & Paint Industry Internship</td></tr>
<tr><td rowspan="2">Teaching Scheme and Credits</td><td>L</td><td>T</td><td>P</td><td colspan="2">Total Contact Hours</td><td colspan="2">Total Credits</td></tr>
<tr><td colspan="4">One Month</td><td colspan="2">03</td></tr>
<tr><td rowspan="2">Evaluation Scheme</td><td colspan="2">ISE</td><td>ESE</td><td>IOE</td><td>IPE</td><td>EOE</td><td>EPE</td><td>Total</td></tr>
<tr><td colspan="2">00</td><td>00</td><td>50</td><td>-</td><td>50</td><td>-</td><td>100</td></tr>
<tr><td>Pre-requisites(if any)</td><td colspan="7">Basics of unit processes and unit operations.</td></tr>
<tr><td>Course Rationale</td><td colspan="7">The Industrial Internship course caters specifically to B.Tech Chemical Engineering students pursuing additional specialization through the B.Tech Minor program in areas such as Oil & Paint Technology. This course offers practical exposure to industry settings aligned with their chosen sub-specialization, aiming to bridge the gap between theoretical knowledge and practical application. By engaging in a one-month internship, students gain firsthand experience, essential skills, and insights crucial for their future careers in specialized sectors of chemical engineering.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">The course teacher will
1. Help expose students to the 'real' working environment.
2. Promote hands-on experience to the students’ in their related field.
3. Develop synergetic collaboration between industry and the university in promoting a knowledgeable society.
4. Assist in providing the opportunity for students to test their interest in a particular career before permanent commitments are made.
5. Elaborate the dynamic and challenging nature of industrial environments.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">Upon completion of this course, student should be able to
1. Understand industrial processes and operations related to their minor sub-specializations.
2. Apply theoretical concepts to solve practical problems in the industry.
3. Communicate effectively with industry professionals, colleagues, and supervisors.
4. Collaborate efficiently in team environments to complete tasks and projects.
5. Adapt to the dynamic and challenging nature of industrial environments.
6. Reflect on internship experiences for personal and professional growth.</td></tr>
</table>

Course Outcome and Program Outcome Mapping

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	-	-	-	-	-	-	-	-	-	-	-
CO 2	-	3	2	-	-	-	-	-	-	-	-	-
CO 3	-	-	-	-	-	-	-	-	-	3	-	-

CO4	-	-	-	-	-	-	-	-	3	-	-	-
CO5	-	-	-	-	-	2	-	-	-	-	-	3
CO6	-	-	-	-	-	-	-	-	-	-	-	2

Level of Mapping as: Low 1, Moderate 2, High 3

Course Content	Hours
The course consists of a one-month internship in a relevant specialized industry. Students will be placed in companies or organizations that align with their chosen sub-specialization within the field of chemical engineering. During the internship, students will engage in various activities, including but not limited to: 1. Shadowing industry professionals to observe and learn about different processes and operations. 2. Assisting with ongoing projects or research initiatives within the organization. 3. Participating in hands-on tasks related to their minor sub-specialization, under the guidance of experienced mentors. 4. Attending training sessions, workshops, and seminars conducted by the industry to enhance their knowledge and skills. 5. Engaging in discussions and meetings with supervisors and colleagues to gain insights into industry practices, challenges, and innovations. 6. Documenting their internship experience through reports, presentations, or reflective journals. The period of one month for this internship will be during the winter or summer vacations, any such slots 4th Semester onwards.	4 weeks

Course Evaluation Method

The evaluation for the Industrial Internship course will be conducted as follows:

- **Internal Evaluation (50 marks):**
  - Assessment by course teachers based on students' performance during the internship, including attendance, participation, attitude, and contribution to assigned tasks.
  - Evaluation by industrial supervisors on students' professional conduct, technical skills, problem-solving abilities, and overall performance in the workplace.
- **External Evaluation (50 marks):**
  - Evaluation by an external examiner appointed by the institute, who will assess students' internship reports, presentations, or any other documentation submitted at the end of the internship period.
  - The external examiner will review the quality of students' reflections on their internship experience, their ability to apply theoretical knowledge to practical situations, and the depth of their understanding of industry practices and challenges.

The final grades for the Industrial Internship course will be determined based on the combined assessment from both internal and external evaluations.

Reference Books	
1.	Lambourne, R., & Strivens, T. A. (2007). Paint and Surface Coatings: Theory and Practice.
2.	Chan, B., & Cantrill, R. E. (Eds.). (2018). Oils and Fats Authentication: New Analytical Methods

Year, Program, Semester	Specialization Minor III, 4th Semester onwards							
Course Code	SPM 3.5							
Course Category	Project Based Learning							
Course Title	**Mini Project**							
Teaching Scheme and Credits	**L**	**T**	**P**	**Total Contact Hours**		**Total Credits**		
	-	-	-	-		02		
Evaluation Scheme	**ISE**	**ESE**		**IOE**	**IPE**	**EOE**	**EPE**	**Total**
	00	00		50	-	50	-	100
Pre-requisites(if any)	Basics of unit processes and unit operations.							
Course Rationale	This course aims to provide students with practical exposure and hands-on experience in real-world industrial settings, fostering a deeper understanding of theoretical concepts through application. By engaging in this mini project, students will develop essential skills such as problem-solving, teamwork, and communication, preparing them for future challenges in the professional arena in the Oil and Paint Industry.							
Course Objectives	The course teacher will 1. Facilitate application of theoretical knowledge. 2. Guide the students about enhancement of practical skills. 3. Explain about development of industry-relevant competencies.							
Course Outcomes	Upon completion of this course, student should be able to 1. Demonstrate application of theoretical concepts with instructor guidance. 2. Collaborate effectively in instructor-led team-based projects. 3. Communicate findings and insights professionally under instructor supervision.							

Course Outcome and Program Outcome Mapping

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	2	-	-	2	-	-	-	2	-	-	-
CO 2	-	-	3	-	-	-	-	-	3	-	2	1
CO 3	-	-	-	-	-	-	-	-	-	3	-	2

Level of Mapping as: Low 1, Moderate 2, High 3

Course Content

Specialization Minor Program Based Mini Project is a dynamic course designed to bridge the gap between classroom learning and real-world application. All the students will engage themselves in a series of tasks and challenge that will enable them to apply theoretical concepts learned in previous courses to solve practical problems. The project work need to be carried out independently covering a range of topics relevant to their field of study, allowing them to explore different facets of the particular discipline and develop versatile skill sets.

This activity may be planned after 4th Semester and can be completed prior to 8th Semester of their Major studies.

Course Assessment Process

The course evaluation for the internals will be at the course teacher end while there will also be

the external evaluation of the Project work.
The teachers will follow the instructions as below:
Evaluation Format: The evaluation may be conducted using a combination of assessment methods, including:

- Rubric-based assessment for the project work and its report.
- Peer evaluation for project.
- Instructor-led discussions or presentations to evaluate communication skills and critical thinking.
- Overall course grading based on a weighted average of individual assessments and participation.

The evaluation format should be transparent, fair, and aligned with the course objectives and outcomes. Regular feedback and communication with students will ensure that the evaluation process remains supportive of their learning journey.

Specialization Minor
In
Green Energy and Chemicals
For
B.Tech (Chemical Engineering)

Shivaji University, Kolhapur
Department of Technology

Specialization Minor in Green Energy and Chemicals

Teaching & Evaluation Scheme

Sr. No.	Category	Course Code	Course Title	Hours per week			Contact Hours	Credits	Evaluation Scheme	
									Theory	Practical
				L	T	P			ISE:ESE	IE:EE
1.	Preferably on SWAYAM (NPTEL) or any other MOOCs (Minor Program Core) Or In a Face-to-Face mode	SPM 4.1	Renewable Energy Generation	03	-	-	03	03	30:70	00:00
2.		SPM 4.2	Technologies for Green Chemicals	03	-	-	03	03	30:70	00:00
3.		SPM 4.3	Carbon Capture and Biomass Gasification	03	-	-	03	03	30:70	00:00
4.	Minor Program Based Internship	SPM 4.4	Green Energy and Chemicals related Industry Internship	One Month				03	00:00	50:50
5.	Project Based Learning	SPM 4.5	Mini Project	-	-	-	-	02	-	50:50
				-	-	-	-	14	300	200
			Total Hours	09	00	00	09	-	-	-

Note: If opted the Specialization Minor Program, Internship and Mini Project may be planned during winter or summer vacation days after 4th semester while respective evaluations will appear on a separate mark sheet.

Specialization Minor IV: Green Energy and Chemicals

Year, Program, Semester	Specialization Minor IV, 4th Semester onwards							
Course Code	SPM-4.1							
Course Category	Specialization Minor Program Core							
Course Title	**Renewable Energy Generation**							
Teaching Scheme and Credits	L	T	P	Total Contact Hours		Total Credits		
	03	-	-	03		03		
Evaluation Scheme	ISE	ESE	IOE	IPE	EOE	EPE	Total	
	30	70	-	-	-	-	100	
Pre-requisites(if any)	Basics of unit processes and unit operations							
Course Rationale	Renewable energy sources play a crucial role in mitigating climate change and reducing dependence on fossil fuels. Understanding the principles and technologies behind renewable energy generation is essential for students interested in sustainable energy solutions.							
Course Objectives	The Course Teacher will 1. Provide students with a comprehensive understanding of various renewable energy sources. 2. Familiarize students with the principles and working mechanisms of renewable energy technologies. 3. Enable students to analyze and evaluate the feasibility of renewable energy projects.							
Course Outcomes	Upon completion of this course, student should be able to 1. Identify and differentiate between different renewable energy sources. 2. Analyze the performance and efficiency of renewable energy systems. 3. Design basic renewable energy systems for specific applications.							

Course Outcome and Program Outcome Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO 12
CO 1	3	-	-	-	-	-	-	-	-	-	-	-
CO 2	-	3	-	-	-	-	-	-	-	-	-	-
CO 3	-	-	3	-	-	-	-	-	-	-	-	-

Level of Mapping as: Low 1, Moderate 2, High 3

Unit No.	Course Content	Hours
I	**Introduction to Renewable Energy** Overview of Renewable Energy: This unit introduces students to the concept of renewable energy and its significance in addressing global energy challenges. It covers various renewable energy sources such as solar, wind, hydro, biomass, and geothermal energy, highlighting their characteristics, advantages, and limitations.	05
II	**Solar Energy Technologies** Principles of Solar Energy: Students delve into the fundamental principles underlying solar energy conversion, including the photovoltaic effect and solar thermal energy conversion. They learn about different types of solar photovoltaic (PV) cells, their operating principles, and efficiency factors. Solar PV Systems: This unit covers the components and configurations of solar PV systems, including solar panels, inverters, charge controllers, and battery storage. Students gain insights into system sizing, integration, and performance optimization techniques. Solar Thermal Systems: Students explore the principles and applications of solar thermal systems for electricity generation and thermal energy production. Topics include concentrating solar power (CSP) technologies, solar collectors, heat transfer fluids, and thermal energy storage.	08
III	**Wind Energy Technologies** Wind Energy Conversion Systems: Students learn about the conversion of wind energy into mechanical and electrical power. Topics include wind turbine components, aerodynamics of wind turbine blades, generator types, and power electronics. Wind Turbine Design and Analysis: This unit focuses on the design considerations and performance analysis of wind turbines. Students study turbine aerodynamics, rotor dynamics, blade design methodologies, and turbine control strategies. Site Selection and Environmental Impact Assessment: Students understand the importance of site selection for wind energy projects and the environmental considerations involved. They learn about wind resource assessment techniques, site suitability criteria, and environmental impact assessment methodologies.	06
IV	**Hydro and Biomass Energy** Hydroelectric Power Generation: This unit explores the principles of hydroelectric power generation, including the design and operation of hydroelectric dams, turbines, and generators. Students examine different types of hydroelectric plants, such as run-of-river, reservoir, and pumped storage systems. Biomass Energy Conversion Processes: Students investigate biomass energy conversion technologies, including combustion, gasification, and anaerobic digestion. They learn about biomass feedstock types, conversion pathways, process efficiencies, and environmental impacts.	06
V	**Geothermal Energy and Emerging Technologies** Geothermal Energy Extraction Methods: This unit covers geothermal energy resources, reservoir characteristics, and exploration techniques. Students learn about geothermal power plant configurations, heat extraction methods, and reinjection practices. Emerging Renewable Energy Technologies: Students explore innovative renewable energy technologies, such as tidal energy, wave energy, and ocean thermal energy conversion (OTEC). They assess the potential, challenges, and current developments in these emerging technologies.	06

VI	**Feasibility Analysis and Project Design** Feasibility Assessment: Students learn the process of evaluating the feasibility of renewable energy projects, considering technical, economic, and environmental factors. Topics include resource assessment, cost-benefit analysis, risk assessment, and regulatory requirements. Project Planning and Design: This unit focuses on the planning and design aspects of renewable energy projects. Students develop skills in project management, system design, equipment selection, and integration of renewable energy systems with existing infrastructure.	**05**
Text Books		
1.	Boyle, G. (2012), Renewable Energy: Power for a Sustainable Future.	
2.	Manwell, J.F., McGowan, J.G., & Rogers, A.L. (2009). Wind Energy Explained.	
Reference Books		
1.	Duffie, J.A., & Beckman, W.A. (2013). *Solar Engineering of Thermal Processes*.	
2.	Weijia Yang (2019),Hydropower Plants and Power Systems: Dynamic Processes and Control for Stable and Efficient Operation	

Year, Program, Semester	Specialization Minor IV, 4th Semester onwards							
Course Code	SPM-4.2							
Course Category	Specialization Minor Program Core							
Course Title	**Technologies for Green Chemicals**							
Teaching Scheme and Credits	L	T	P	Total Contact Hours		Total Credits		
	03	-		03		03		
Evaluation Scheme	ISE	ESE	IOE	IPE	EOE	EPE	Total	
	30	70	-	-	-	-	100	
Pre-requisites(if any)	Basics of unit processes and unit operations.							
Course Rationale	The production of chemicals often involves processes that are resource-intensive and environmentally damaging. This course aims to introduce students to sustainable practices and technologies in chemical production, focusing on minimizing environmental impact and promoting green chemistry principles.							
Course Objectives	The Course Teacher will 1. Familiarize students with the principles of green chemistry and sustainable chemical processes. 2. Provide students with an understanding of emerging technologies for the production of green chemicals. 3. Enable students to evaluate the environmental and economic feasibility of green chemical processes.							
Course Outcomes	Upon completion of this course, student should be able to 1. Apply green chemistry principles to design environmentally benign chemical processes. 2. Analyze the environmental impacts of conventional chemical processes and identify opportunities for improvement. 3. Propose and justify the adoption of green chemical technologies in industrial settings.							

Course Outcome and Program Outcome Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO 12
CO 1	3	-	-	-	-	-	-	-	-	-	-	-
CO 2	-	3	-	-	-	-	-	-	-	-	-	-
CO 3	-	-	3	-	-	-	-	-	-	-	-	-

Level of Mapping as: Low 1, Moderate 2, High 3

Unit No.	Course Content	Hours
I	Introduction to Green Chemistry: This unit provides an overview of green chemistry principles and their significance in chemical production. Topics include the twelve principles of green chemistry, solvent selection, and waste minimization strategies.	06
II	Sustainable Synthesis Methods: Students learn about sustainable synthesis methods, including catalysis, bio-catalysis, and microwave-assisted synthesis. Emphasis is placed on reducing energy consumption, waste generation, and hazardous chemical use.	09
III	Renewable Feed-stocks: This unit explores the utilization of renewable feed-stocks in chemical synthesis, such as biomass-derived sugars, oils, and lingo-cellulosic materials. Students examine conversion technologies and assess their sustainability and scalability	07
IV	Process Intensification: Students study process intensification techniques aimed at improving resource efficiency and reducing environmental impact. Topics include micro-reactors, continuous flow processes, and integrated reaction-separation systems.	06
V	Green Solvents and Separation Methods: This unit focuses on the selection and design of green solvents and separation methods in chemical processes. Students explore solvent properties, extraction techniques, and membrane separation processes.	06
VI	Life Cycle Assessment (LCA) and Sustainability Metrics: Students learn about life cycle assessment methodologies and sustainability metrics for evaluating the environmental performance of chemical processes. They conduct case studies and analyze environmental impacts across the life cycle of chemical products.	05
Text Books		
1.	Anastas, P.T., & Warner, J.C. (1998). Green Chemistry: Theory and Practice.	
2.	Ram, M.K., & Bhaumik, P. (2013). Introduction to Green Chemistry: Principles, Applications and Challenges	
Reference Books		
1.	Bommarius, A.S., & Pfeifer, B. (2006). Biocatalysis: Fundamentals and Applications.	
2.	Dos Santos, M.F., Coutinho, J.A.P., & Gomes, S.S. (2020). Green Solvents: Properties and Applications in Chemistry.	

Year, Program, Semester	Specialization Minor IV, 4th Semester onwards							
Course Code	SPM-4.3							
Course Category	Specialization Minor Program Core							
Course Title	**Carbon Capture and Biomass Gasification**							
Teaching Scheme and Credits	L	T	P	Total Contact Hours		Total Credits		
	03	-	-	03		03		
Evaluation Scheme	ISE	ESE	IOE	IPE	EOE	EPE	Total	
	30	70	-	-	-	-	100	
Pre-requisites(if any)	Basics of unit processes and unit operations.							
Course Rationale	This course addresses the urgent need to reduce greenhouse gas emissions and utilize biomass resources effectively. Students will learn about carbon capture technologies for mitigating CO2 emissions from industrial processes and power plants, as well as biomass gasification techniques for renewable energy production.							
Course Objectives	The course teacher will 1. Provide students with an understanding of carbon capture methods and technologies. 2. Familiarize students with biomass gasification processes for renewable energy generation. 3. Enable students to assess the feasibility and potential environmental impacts of carbon capture and biomass gasification projects.							
Course Outcomes	The students will be able to 1. Explain the principles and mechanisms of carbon capture technologies. 2. Analyze the efficiency and cost-effectiveness of different biomass gasification processes. 3. Design and evaluate carbon capture and biomass gasification systems for specific applications.							

Course Outcome and Program Outcome Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO 12
CO 1	3	-	-	-	-	1	-	-	-	-	-	-
CO 2	-	3	-	-	-	1	-	-	-	-	-	-
CO 3	-	-	3	-	-	1	-	-	-	-	-	-

Level of Mapping as: Low 1, Moderate 2, High 3

Unit No.	Course Content	Hours
I	Fundamentals of Carbon Capture: Introduction to carbon capture techniques, including pre-combustion, post-combustion, and oxy-fuel capture methods. Students learn about capture materials, separation processes, and CO2 storage options.	**06**
II	Carbon Capture Technologies: Exploration of carbon capture technologies, such as absorption, adsorption, membrane separation, and cryogenic distillation. Case studies highlight the application of these technologies in various industries.	**09**
III	Carbon Capture System Design: Study of the design considerations and engineering aspects of carbon capture systems. Topics include process integration, equipment sizing, energy requirements, and techno-economic analysis.	**07**
IV	Biomass Gasification Processes: Overview of biomass gasification as a thermochemical conversion process for producing syngas (mixture of hydrogen and carbon monoxide). Students learn about gasification reactor types, feedstock characteristics, and gas cleanup techniques.	**06**
V	Syngas Utilization and Conversion: Examination of syngas utilization pathways, including combustion, gas turbines, fuel cells, and synthesis of chemicals and fuels (e.g., methanol, synthetic natural gas).	**06**
VI	Environmental Impact Assessment and Regulatory Compliance: Introduction to environmental impact assessment (EIA) methodologies for carbon capture and biomass gasification projects. Students analyze potential environmental impacts, regulatory requirements, and mitigation measures.	
Text Books		
1.	B. R. Gurjar & C. S. P. Ojha, (2015). Carbon Capture and Storage: Physical, Chemical, and Biological Methods.	
2.	Basu, P. (2010). Biomass Gasification and Pyrolysis: Practical Design and Theory.	
Reference Books		
1.	Reed, T.B., & Das, A. (1988). Handbook of Biomass Downdraft Gasifier Engine Systems.	
2.	Wu, C, & Zhang, Y. (2019),Carbon Capture and Utilization in the Greenhouse Gas Market.	

<table>
<tr><td>Year, Program, Semester</td><td colspan="7">Specialization Minor IV, 4th Semester onwards</td></tr>
<tr><td>Course Code</td><td colspan="7">SPM-4.4</td></tr>
<tr><td>Course Category</td><td colspan="7">Program Based Internship</td></tr>
<tr><td>Course title</td><td colspan="7">Green Energy & Chemicals Related Industry Internship</td></tr>
<tr><td rowspan="2">Teaching Scheme and Credits</td><td>L</td><td>T</td><td>P</td><td colspan="2">Total Contact Hours</td><td colspan="2">Total Credits</td></tr>
<tr><td colspan="5">One Month</td><td colspan="2">03</td></tr>
<tr><td rowspan="2">Evaluation Scheme</td><td colspan="2">ISE</td><td>ESE</td><td>IOE</td><td>IPE</td><td>EOE</td><td>EPE</td><td>Total</td></tr>
<tr><td colspan="2">00</td><td>00</td><td>50</td><td>-</td><td>50</td><td>-</td><td>100</td></tr>
<tr><td>Pre-requisites(if any)</td><td colspan="7">Basics of unit processes and unit operations.</td></tr>
<tr><td>Course Rationale</td><td colspan="7">The Industrial Internship course caters specifically to B.Tech Chemical Engineering students pursuing additional specialization through the B.Tech Minor program in areas such as Green Energy & Chemicals. This course offers practical exposure to industry settings aligned with their chosen sub-specialization, aiming to bridge the gap between theoretical knowledge and practical application. By engaging in a one-month internship, students gain firsthand experience, essential skills, and insights crucial for their future careers in specialized sectors of chemical engineering.</td></tr>
<tr><td>Course Objectives</td><td colspan="7">The course teacher will
1. Help expose students to the 'real' working environment.
2. Promote hands-on experience to the students’ in their related field.
3. Develop synergetic collaboration between industry and the university in promoting a knowledgeable society.
4. Assist in providing the opportunity for students to test their interest in a particular career before permanent commitments are made.
5. Elaborate the dynamic and challenging nature of industrial environments.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">Upon completion of this course, student should be able to
1. Understand industrial processes and operations related to their minor sub-specializations.
2. Apply theoretical concepts to solve practical problems in the industry.
3. Communicate effectively with industry professionals, colleagues, and supervisors.
4. Collaborate efficiently in team environments to complete tasks and projects.
5. Adapt to the dynamic and challenging nature of industrial environments.
6. Reflect on internship experiences for personal and professional growth.</td></tr>
</table>

Course Outcome and Program Outcome Mapping

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	-	-	-	-	-	-	-	-	-	-	-
CO 2	-	3	2	-	-	-	-	-	-	-	-	-
CO 3	-	-	-	-	-	-	-	-	-	3	-	-
CO 4	-	-	-	-	-	-	-	-	3	-	-	-
CO 5	-	-	-	-	-	2	-	-	-	-	-	3
CO 6	-	-	-	-	-	-	-	-	-	-	-	2

Level of Mapping as: Low 1, Moderate 2, High 3

Course Content	**Hours**
The course consists of a one-month internship in a relevant specialized industry. Students will be placed in companies or organizations that align with their chosen sub-specialization within the field of chemical engineering. During the internship, students will engage in various activities, including but not limited to: 1. Shadowing industry professionals to observe and learn about different processes and operations. 2. Assisting with ongoing projects or research initiatives within the organization. 3. Participating in hands-on tasks related to their minor sub-specialization, under the guidance of experienced mentors. 4. Attending training sessions, workshops, and seminars conducted by the industry to enhance their knowledge and skills. 5. Engaging in discussions and meetings with supervisors and colleagues to gain insights into industry practices, challenges, and innovations. 6. Documenting their internship experience through reports, presentations, or reflective journals. The period of one month for this internship will be during the winter or summer vacations, any such slots 4th Semester onwards.	4 weeks

Course Evaluation Method

The evaluation for the Industrial Internship course will be conducted as follows:

- **Internal Evaluation (50 marks):**
    - Assessment by course teachers based on students' performance during the internship, including attendance, participation, attitude, and contribution to assigned tasks.
    - Evaluation by industrial supervisors on students' professional conduct, technical skills, problem-solving abilities, and overall performance in the workplace.
- **External Evaluation (50 marks):**

- Evaluation by an external examiner appointed by the institute, who will assess students' internship reports, presentations, or any other documentation submitted at the end of the internship period.
- The external examiner will review the quality of students' reflections on their internship experience, their ability to apply theoretical knowledge to practical situations, and the depth of their understanding of industry practices and challenges.

The final grades for the Industrial Internship course will be determined based on the combined assessment from both internal and external evaluations.

Reference Books	
1.	Thumann, A., & Younger, W.J. (2010). Handbook of Energy Audits.
2.	Turner, W.C., & Doty, S. (2017). Energy Management Handbook.

Year, Program, Semester	Specialization Minor IV, 4th Semester onwards						
Course Code	SPM 4.5						
Course Category	Project Based Learning						
Course Title	**Mini Project**						
Teaching Scheme and Credits	**L**	**T**	**P**	**Total Contact Hours**		**Total Credits**	
	-	-	-	-		02	
Evaluation Scheme	**ISE**	**ESE**	**IOE**	**IPE**	**EOE**	**EPE**	**Total**
	00	00	50	-	50	-	100
Pre-requisites(if any)	Basics of unit processes and unit operations.						
Course Rationale	This course aims to provide students with practical exposure and hands-on experience in real-world industrial settings, fostering a deeper understanding of theoretical concepts through application. By engaging in this mini project, students will develop essential skills such as problem-solving, teamwork, and communication, preparing them for future challenges in the professional arena in green aspects of Industry.						
Course Objectives	The course teacher will 1. Facilitate application of theoretical knowledge. 2. Guide the students about enhancement of practical skills. 3. Explain about development of industry-relevant competencies.						
Course Outcomes	Upon completion of this course, student should be able to 1. Demonstrate application of theoretical concepts with instructor guidance. 2. Collaborate effectively in instructor-led team-based projects. 3. Communicate findings and insights professionally under instructor supervision.						

Course Outcome and Program Outcome Mapping

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	2	-	-	2	-	-	-	2	-	-	-
CO 2	-	-	3	-	-	-	-	-	3	-	2	1
CO 3	-	-	-	-	-	-	-	-	-	3	-	2

Level of Mapping as: Low 1, Moderate 2, High 3

Course Content

Specialization Minor Program Based Mini Project is a dynamic course designed to bridge the gap between classroom learning and real-world application. All the students will engage themselves in a series of tasks and challenge that will enable them to apply theoretical concepts learned in previous courses to solve practical problems. The project work need to be carried out independently covering a range of topics relevant to their field of study, allowing them to explore different facets of the particular discipline and develop versatile skill sets pertaining to application of Green Technology.

This activity may be planned after 4th Semester and can be completed prior to 8th Semester of their Major studies.

Course Assessment Process
The course evaluation for the internals will be at the course teacher end while there will also be the external evaluation of the Project work. The teachers will follow the instructions as below: Evaluation Format: The evaluation may be conducted using a combination of assessment methods, including: • Rubric-based assessment for the project work and its report. • Peer evaluation for project. • Instructor-led discussions or presentations to evaluate communication skills and critical thinking. • Overall course grading based on a weighted average of individual assessments and participation. The evaluation format should be transparent, fair, and aligned with the course objectives and outcomes. Regular feedback and communication with students will ensure that the evaluation process remains supportive of their learning journey.