K. K. Wagh Institute of Engineering Education and Research, Nashik

(Autonomous wef AY 2022-23)

Syllabus B. Tech Chemical Engineering (Honors/Minors)

Pattern: 2022 Pattern

(wef AY 2022-23)

B. Tech (Chemical Engineering) with Honors/Minors in Process Engineering
(2022 Pattern)

Sem	Course Type	Course Code	Title of Course	Teaching Scheme			Evaluation Scheme and Marks						Credits			
				TH	TU	PR	INSEM	ENDSEM	CCE	TW	PR	TOTAL	TH	TU	PR	TOTAL
VI	DCC	CHE223021	Process Intensification	04	-	-	20	60	20	-	-	100	04	-	-	04
	DCC	CHE223022	Lab Course in Process Intensification	-	-	04	-	-	-	50	50	100	-	-	02	02
VII	DCC	CHE224021	Process Technology	04	-	-	20	60	20	-	-	100	04	-	-	04
	DCC	CHE224022	Lab Course in Process Technology	-	-	04	-	-	-	50	50	100	-	-	02	02
VIII	DCC	CHE224023	Mass Transfer with Reactions	03	-	-	20	60	20	-	-	100	03	-	-	03
	DCC	CHE224024	Process Utilities	03	-	-	20	60	20	-	-	100	03	-	-	03
	Total			**14**	**-**	**08**	**80**	**240**	**80**	**100**	**100**	**600**	**14**	**-**	**04**	**18**

Dr. S. N. Jain
Chairman, BoS

Dr. K. N. Nandurkar
Director

K. K. Wagh Institute of Engineering Education and Research, Nashik

(Autonomous from Academic Year 2022-23)

Semester VI (TY - B. Tech.) Chemical Engineering **CHE223021: Process Intensification**		
Teaching Scheme: **Theory: 04 hrs/week**	**Credit :04**	**Examination scheme:** **In Semester Exam: 20 marks** **End Semesters Exam: 60 marks** **Continuous Comprehensive Evaluation: 20 marks** **Total: 100 Marks**

Prerequisite: Fundamentals of Chemical Engineering, Unit Operations and Unit Processes. Chemical Reaction Engineering, Process Control and Instrumentation
Basic Process Simulation Tools

Course Objectives:

1. Understand the fundamentals of process intensification, including its definition, historical development, and principles for sustainability, economics, and safety.
2. Analyze and apply various intensified heat exchangers, such as microchannel and printed circuit heat exchangers, in chemical industries.
3. Explore advanced mass transfer techniques, including rotating packed beds, membrane processes, and reactive distillation, and their energy-based intensifications.
4. Implement advanced mixing and reactor technologies, such as microfluidics and plasma-assisted reactors, and understand their applications in process intensification.
5. Utilize process design and simulation tools like Aspen Plus and ANSYS Fluent, focusing on process control, automation, optimization, and safety in intensified processes.

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

Sr. No.	**Course Outcomes**	**Bloom's Level**
CO1	Define process intensification, its history, and principles, and compare conventional and intensified processes.	4-Analyze
CO2	Design and evaluate intensified heat exchangers and their applications in chemical industries.	5-Evaluate
CO3	Apply advanced mass transfer techniques and energy-based intensifications.	3-Apply
CO4	Implement and assess various intensified mixing and reactor technologies.	4-Analyze
CO5	Use simulation tools (Aspen Plus, ANSYS Fluent) for process design, control, optimization, and safety considerations.	5-Evaluate

Course Contents:

Unit I	**Introduction of Process Intensification Techniques**	**(L06)**	**COs Mapped: CO1**

Definition and historical development of PI, PI for Sustainability, economics, and safety, Principles and Domains of Process Intensification (PI), Overview of conventional vs intensified processes, Benefits of Intensified Processes, Process synthesis and design approaches, Concepts of miniaturization, multifunctional reactors, and integrated processes, PI for energy and material savings.
PI Toolbox – Equipments and Methods, Active and Passive Techniques.

Unit II	**Intensified Heat Exchangers**	**(L08)**	**COs Mapped: All**

			COs
Heat transfer intensification, Microchannel (Microheat) heat exchangers and compact heat exchangers, Applications in chemical industries, Plate heat exchanger, spiral heat exchanger			
Unit III	**Enhanced Mass Transfer**	**(L08)**	**COs Mapped: All COs**
Rotating Packed Beds (RPBs/HiGee), Membrane-based Processes, Microreactors and Microstructured Devices, Reactive Distillation, Dividing-Wall Columns (DWCs), Centrifugal Extractor, Reactive distillation, Reactive absorption, Reactive extraction, Reactive membrane separations. Energy based intensifications, Sonochemistry, Microwaves			
Unit IV	**Intensified Mixing & Reactors**	**(L08)**	**COs Mapped: All COs**
Microfluids, Static Mixer, coalescence device, Spinning Disc Reactors (SDRs), High-Intensity Ultrasound (Sonochemistry), High-Pressure Homogenization, Plasma-Assisted Reactors, Confined Impinging Jet Reactors (CIJR), Microwave-Assisted Reactors, Electrochemical Reactors, Photocatalytic Reactors, Microstructured (microchannel) reactors, Membrane reactors combining reaction and separation.			
Unit V	**Process Design and Simulation Tools for PI**	**(L10)**	**COs Mapped: All COs**
Introduction to Process Simulation Tools, Aspen Plus, ANSYS Fluent for PI, Process Control and Automation in PI, Optimization and Safety Considerations in PI			

Reference Books

1. Process Intensification: Engineering for Efficiency, Sustainability and Flexibility, D. Reay, C. Ramshaw, and A. Harvey, 2nd Edition, Butterworth-Heinemann.
2. Process Intensification Technologies for Green Chemistry, K. Boodhoo, and A. Harvey, John Wiley & Sons.
3. Re-Engineering the Chemical Processing Plant: Process Intensification, A. Stankiewicz, and J.A. Moulijn, Marcel Dekker.
4. Modeling of Process Intensification, F. J. Keil, WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim.
5. The Fundamentals of Process Intensification, Andrzej Stankiewicz, Tom van Gerven, Georgios Stefanidis, Wiley VCH.

Sr. No.	**Components for Continuous Comprehensive Evaluation**	**Marks Allotted**
1	Three Assignments on unit-1, unit-2, unit-3 & 4	10
2	Group Presentation on unit-5	05
3	LMS Test on each unit	05
	Total	**20**

K. K. Wagh Institute of Engineering Education and Research, Nashik

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Semester V (TY - B. Tech.) Chemical Engineering **CHE223022: Lab Course in Process Intensification**		
Teaching Scheme: Practical: 04 hrs/week	**Credit Scheme: 02**	**Examination scheme:** **TW: 50 marks** **Oral: 50 marks** **Total: 100 Marks**

Prerequisite: Fundamentals of Chemical Engineering, Unit Operation and Unit Processes.

Course Objectives:

1. Understand the principles and applications of ultrasound in process intensification
2. Investigate the principles and operation of reactive distillation
3. Explore the utilization of microwave-assisted processes for enhanced chemical reactions
4. Study the design and operation of microreactors for intensified chemical processes

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

Sr. No.	Course Outcomes	Bloom's Level
CO1	Apply the ultrasound techniques for process intensification, design optimized chemical processes via reactive distillation.	3-Apply
CO2	Evaluate the performance of microwave-assisted reactions and analyze microreactor performance for intensified processes	5-Evaluate
CO3	Demostrate compact heat exchangers, solar detox and photocatalytic oxidation reactor.	3-Apply
CO4	Enhance mixing efficiency in tanks and analyze its impact on processes and product quality.	4-Analyze

List of Laboratory Experiments / Assignments

Sr. No	List of experimets	CO Mapping
1	Study of Ultrasonication.	**CO1**
2	Study of Reactive Distillation	**CO1**
3	Study of Microwave-Assisted Processes	**CO2**
4	Study of Micro-reactors	**CO2**
5	Study of Compact Heat Exchangers	**CO3**
6	Study of Solar Detoxification	**CO3**
7	Study of Photocatalytic oxidation.	**CO4**
8	Study of Enhanced Mixing Efficiency in Stirred Tanks	**CO4**

Guidelines for Termwork Assessment

Term work assessment is to be based on overall performance of students, which includes the following parameters: timely completion of tasks, performance quality, punctuality, participation, and contribution in the experiments. Students will be evaluated based on the experiment, report and presentation.

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Semester VII (TY - B. Tech.) Chemical Engineering **CHE224021:Process Technology**		
Teaching Scheme: **Theory : 04hrs/week**	**Credit :** **04**	**Examination Scheme:** **Continuous Comprehensive Evaluation: 20 Marks** **InSem Exam: 20 Marks** **EndSem Exam: 60 Marks** **Total: 100 Marks**

Prerequisite: Basic knowledge of chemical process calculations, thermodynamics, heat and mass transfer, reaction engineering, and unit operations.

Course Objectives:

1. Provide knowledge of process flow diagrams (PFDs) and piping and instrumentation diagrams as essential tools for process design and development.
2. Develop the ability to integrate safety, environmental, and economic aspects into holistic process development.
3. Familiarize students with recent advancements in organic, inorganic, polymer, and catalytic processes.
4. Introduce the principles of green technologies, sustainable process practices, and circular economy concepts.
5. Explore bio-refinery technologies for conversion of biomass into biofuels, bio-chemicals, and bio-materials, including relevant industrial applications.

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

	Course Outcomes	**Bloom'sLevel**
CO1	Develop process flow sheets while incorporating environmental, safety, and economic considerations.	**3-Apply**
CO2	Identify and analyze recent technological advancements in organic and inorganic process technologies.	**4 -Analyze**
CO3	Apply green technologies and sustainable chemical engineering practices to improve process efficiency and minimize environmental impact.	**3-Apply**
CO4	Implement circular economy principles and sustainability practices, with a special focus on the sugar industry and other process sectors.	**5-Evaluate**
CO5	Evaluate the applications of bio-refinery processes to enhance biomass valorization in different industrial sectors.	**5-Evaluate**

COURSE CONTENTS

Unit I	**Process Development**	**(08hrs)**	**CO1**

Flow Sheet Development: Fundamentals of process design, process flow diagrams (PFDs), piping and instrumentation diagrams (P&IDs). **Holistic Process Development:** Integration of environmental, safety, and economic considerations in process design.

Unit II	**Recent Advancements in Process Technologies**	**(08hrs)**	**CO2**

Organic Processes: Innovations in the production of organic chemicals, pharmaceuticals, and polymers. **Catalysis in Organic Synthesis:** Green catalysis, biocatalysts, photo-catalysis, transition metal catalysts, and electro-catalysis. **Polymer Chemistry and**

Technology: Biodegradable polymers, recyclable and circular polymers, 3D printing of polymers, smart polymers, and nanopolymers. **Inorganic Processes:** Technological advancements in metallurgy, fertilizers, cement, and inorganic chemical production.			
Unit III	**Green Technology**	**(08hrs)**	**CO3**
Introduction to Green Technologies: Definitions, principles, and applications in process industries. **Green Chemistry and Sustainable Processes:** Atom economy, solvent-free reactions, carbon capture and utilization (CCU), waste minimization, and reuse. **Industrial Applications:** Case studies on energy-efficient and low-emission process technologies.			
Unit IV	**Sustainability and Circular Economy**	**(08hrs)**	**CO4**
Concept of Sustainability: Overview of sustainable practices in the process industries. **Circular Economy Principles:** Reduce, reuse, and recycle approaches, with a focus on the sugar industry. **Case Study: Sugar Industry:** Implementation of sustainability and circular economy strategies in sugar production, recycling, and waste utilization.			
Unit V	**Bio-Refinery Processes**	**(08hrs)**	**CO5**
Introduction to Bio-Refinery: Concepts, biomass conversion processes, and value-added products. Bio-Refinery Technologies: Biomass conversion into biofuels, bio-chemicals, and bio-materials. Discussion on feedstock selection and process design. Industrial Applications: Case studies of bio-refineries in the food, energy, and chemical industries.			

Reference Books

1. Process Systems Analysis and Control, D.R. Coughanowr, McGraw-Hill Education, 3rd Edition, 2009.
2. Unit Operations of Chemical Engineering, Warren McCabe, Julian Smith, Peter Harriott, McGraw-Hill Education, 7th Edition, 2005.
3. Green Chemistry and Engineering: A Practical Design Approach, Concepción Jiménez-González, Wiley, 1st Edition, 2011.
4. The Circular Economy: A User's Guide, Walter R. Stahel, Routledge, 1st Edition, 2019.

Guidelines for Continuous Comprehensive Evaluation of Theory Course		
Sr. No.	**Components for Continuous Comprehensive Evaluation**	**Marks Allotted**
1	LMS Test / Assignment on Problem solving through Tutorial / Group presentation on real life problem	20

K. K. Wagh Institute of Engineering Education and Research, Nashik

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Semester VII (TY - B. Tech.) Chemical Engineering **CHE224022: Lab work in Process Technology,**		
Teaching Scheme: **Practical: 04 hrs/week**	**Credit:** **02**	**Examination Scheme:** **Practical: 50 Marks** **Term Work: 50 Marks** **Total:100 Marks**

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

	Course Outcomes	**Bloom'sLevel**
CO1	Design and simulate process flow sheets integrating environmental, safety, and economic considerations using software tools.	**3-Apply**
CO2	Conduct experimental analysis and interpret data from emerging organic and inorganic process technologies.	**4 -Analyze**
CO3	Demonstrate the implementation of green chemistry principles and sustainable practices in laboratory-scale processes.	**3-Apply**
CO4	Evaluate process sustainability and circular economy strategies through practical applications.	**5-Evaluate**
CO5	Evaluate bio-refinery process experiments for biomass utilization and product development.	**5-Evaluate**

List of Laboratory Experiments/ Assignments

Sr. No.	**Laboratory Experiments/Assignments**	**CO Mapped**
1.	Development of process flow diagrams (PFDs) or piping and instrumentation diagrams (P&IDs) using DWSIM/ Aspen Plus/UniSim	**CO1**
2.	Case study on a selected chemical process.	**CO2**
3.	Synthesis and characterization of biodegradable polymers.	**CO3**
4.	Synthesis of catalyst and its applications using photocatalytic reactor	**CO2**
5.	Waste minimization and case studies on zero waste discharge	**CO3**
6.	Case study on Energy-efficient process analysis in chemical reactions.	**CO2,CO3**
7.	Recycling and reuse of industrial by-products (case study utilization on any industry).	**CO4**
8.	Water and energy conservation techniques in process industries.	**CO4**
9.	Conversion of biomass into biofuels (Biodiesel production from vegetable oils or waste oils).	**CO5**
10.	Bio-based chemical production and analysis.	**CO5**

Guidelines for Laboratory Conduction

1. Experiments should be performed in a group of two students only.
2. Avoid contacting circuits with weth and sor wet materials.
3. Double check circuits for proper connections and polarity prior to applying the power.
4. Observe polarity when connecting polarized components or test equipment.
5. Make sure test instruments are set for proper function and range prior to taking measurement.

Guidelines for Student's Lab Journal

Student's lab journal should contain following related things- Title,Objectives,Hardware/Softwarerequirement,Theory,CircuitDiagram,Observationtable,Graph, Calculations, Results, Conclusion and Assignment questions
Guidelines for Practical and Termwork Assessment
• R1: Timely completion of experiment (10 Marks) • R2: Understanding of experiment (10 Marks) • R3: Presentation /clarity of journal writing (10 Marks) Total 30 marks for each experiment and average marks of all experiments will be converted into 25 marks of Term work

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Semester VIII (TY - B. Tech.) Chemical Engineering **CHE224023:Mass Transfer with Reactions**		
Teaching Scheme: **Theory :03hrs/week**	**Credit :** **03**	**Examination Scheme:** **Continuous Comprehensive Evaluation: 20 Marks InSem Exam: 20 Marks** **EndSem Exam: 60 Marks** **Total: 100 Marks**

Prerequisites: Basics of thermodynamics, reaction engineering, mass transfer, and fluid mechanics.

Course Objectives:

1. Provide knowledge of fundamentals of mass transfer in reactive systems and their role in chemical reaction engineering.
2. Develop understanding of diffusion and reaction mechanisms in gases, liquids, and solids.
3. Analyze heterogeneous mass transfer with reaction in different reactor systems and catalytic processes.
4. Explore reactive separations, micro-reactors, and applications of mass transfer with reaction in sustainable and green technologies.

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

	Course Outcomes	**Bloom'sLevel**
CO1	Apply mass transfer and reaction principles to analyze reactive systems.	3-Appply
CO2	Analyze diffusion and reaction mechanisms in gases, liquids, and solids.	4-Analyze
CO3	Analyze heterogeneous reactions in reactors and evaluate effectiveness factors.	4-Analyze
CO4	Evaluate reactive separations, micro-reactors, and green technology for sustainable solutions.	5-Evaluate

COURSE CONTENTS

Unit I	**Fundamentals of Mass Transfer with Chemical Reactions**	**(08hrs)**	**CO1**

Basics of mass transfer in reactive systems, Role of interface mass transfer in chemical reactions,· Classification: Homogeneous & Heterogeneous reactions, Theories of mass transfer (Film theory, Penetration theory, Surface renewal theory), Dimensionless numbers relevant to mass transfer with reaction

Unit II	**Diffusion and Reaction Mechanisms**	**(08hrs)**	**CO2**

Diffusion models: Fick's Law, Maxwell-Stefan diffusion, Diffusion in gases, liquids, and solids with reaction, Enhancement factors and film theories in diffusion-controlled reactions, Applications in absorption with chemical reaction (e.g., CO_2 absorption in amine solutions).

Unit III	**Mass Transfer with Heterogeneous Reactions**	**(08hrs)**	**CO3**
Mass transfer across phase boundaries, Effectiveness factor and Thiele modulus, Modeling of gas-solid and liquid-solid reactions, Slurry reactors, trickle-bed reactors, and fluidized bed reactors, Catalyst pore diffusion and reaction.			
Unit IV	**Reactive Separations**	**(08hrs)**	**CO3, CO4**
Reactive distillation, Study of reactive separation columns, Equilibrium and rate-based modeling of reactive separations, Membrane reactors, Role of catalysts in mass transfer-reaction systems.			
Unit V	**Applications and Advanced Topics**	**(08hrs)**	**CO4**
Micro-reactors and intensified reactive mass transfer, Green chemistry applications (Hydrogen production, Biofuel synthesis), Applications in environmental engineering (e.g., pollutant removal).			

ReferenceBooks

1. Mass Transfer Operations, R.E. Treybal, McGraw-Hill, 3rd Edition, 1981.
2. Chemical Reaction Engineering, Octave Levenspiel, John Wiley & Sons, 3rd Edition, 1999.
3. Elements of Chemical Reaction Engineering, H. Scott Fogler, Prentice Hall, 5th Edition, 2016.
4. Mass Transfer with Chemical Reactions, J. M. Coulson and J. F. Richardson, Chemical Engineering Series, Elsevier, 6th Edition, 2005.
5. Process Intensification in Chemical Engineering, Andrzej Stankiewicz, Tom Van Gerven, Wiley-VCH, 2008.
6. Handbook of Heterogeneous Catalysis, G. Ertl, H. Knözinger, F. Schüth, J. Weitkamp, Wiley-VCH, 2nd Edition, 2008.
7. hemical Engineering Design: Principles, Practice and Economics of Plant and Process Design, J.M. Coulson, J.F. Richardson, R.K. Sinnott, Elsevier, 6th Edition, 2005.

Guidelines for Continuous Comprehensive Evaluation of Theory Course		
Sr. No.	**Components for Continuous Comprehensive Evaluation**	**Marks Allotted**
1	LMS Test / Assignment on Problem solving through Computational Software / Tutorial / Group presentation on real life problem	20

K. K. Wagh Institute of Engineering Education and Research, Nashik

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Semester VIII (TY - B. Tech.) Chemical Engineering **CHE224024: Process Utilities**		
Teaching Scheme: **Theory :03hrs/week**	**Credit :** **03**	**Examination Scheme:** **Continuous Comprehensive Evaluation: 20 Marks** **InSem Exam: 20 Marks** **EndSem Exam: 60 Marks** **Total: 100 Marks**

Prerequisites: Basics of thermodynamics, fluid mechanics, heat transfer, and unit operations.

Course Objectives:

1. Provide knowledge of various process utilities and their role in chemical process industries, including classification, identification, and economic impact.
2. Understand water and steam systems, including water treatment, boiler feed water, steam generation, and utilization in process plants.
3. Study non-steam heating systems such as hot oils, thermic fluids, and fired heaters, including their properties, selection, and industrial applications.
4. Explore other utilities such as compressed air, inert gases, vacuum systems, chilling plants, refrigeration, and electrical power systems in process industries.

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

	Course Outcomes	**Bloom'sLevel**
CO1	Apply knowledge of process utilities and assess their economic impact.	3-Apply
CO2	Analyze water and steam systems for efficient utilization.	4-Analyze
CO3	Examine non-steam heating and other utility systems for industrial applications.	4-Analyze
CO4	Evaluate and optimize utility systems for efficiency, sustainability, and reliability.	5-Evaluate

COURSE CONTENTS

Unit I	**Introduction of utilities:**	**(07hrs)**	**CO1**
Role of Process Utilities in process industries, Classification of process utilities, Impact on Project economics, Colour codes used for identification of process utilities.			
Unit II	**Water**	**(07hrs)**	**CO2**
Water characteristics, conditioning and treatment methods of water for process industries, water softening techniques, De-mineralized Water, Applications of water, Process water, and boiler feed water (BFW) and its characteristics, cooling Water, recycling aspects of water from blow downs			
Unit III	**Steam**	**(07hrs)**	**CO2, CO4**

Properties of steam, Characteristics properties, classification, selection and industrial applications Steam calculations, application of steam systems in chemical process plants, design of efficient steam heating systems, Superheated steam, condensate utilization, flash steam, steam traps, Steam generators, classification, construction features, Boiler Accessories and Mountings, Economiser, super-heater, pre-heater			
Unit IV	**Non-steam heating systems**	**(07hrs)**	**CO3**
Hot Oil/Specialized Heat Transfer Fluids/Thermic Fluids, Mineral oils, Dowtherm - Synthetic Organic Fluids, Dowcal - Inhibited Glycols, Syltherm - Silicone Fluids, Characteristics properties, classification, selection and industrial applications Fuels, Fired heaters			
Unit V	**Other utilities**	**(07hrs)**	**CO3, CO4**
Air: Necessity, process air, instrument air, compressed air, air-water vapour mixture, psychrometry, Characteristics properties, classification, selection and industrial applications, Characteristics of air and air receivers, Inert gases, Inert gas generation Electrical Power: HT/LT, Emergency power. Inverters, DG sets. Etc. Vacuum system engineering, Chilling plant, refrigeration, Emergency Drives Identification			

ReferenceBooks

1. Chemical Plant Utilities, Sathiyamoorthy Manickkam, LAP LAMBERT Academic Publishing, 1st Edition, 2016.
2. A Textbook of Thermal Engineering, R.S. Khurmi, J.K. Gupta, S. Chand Publishing, 1st Edition, 2010.
3. Chemical Engineering, Vol. 6: Chemical Engineering Design, J.M. Coulson, J.F. Richardson, R.K. Sinnott, Elsevier Butterworth-Heinemann, 6th Edition, 1999.
   Steam Generators and Waste Heat Boilers: For Process and Plant Engineers, V. Ganapathy, CRC Press, 1st Edition, 2017.
4. Fuels and Combustion, Samir Sarkar, Orient BlackSwan, 1st Edition, 2009.

Guidelines for Continuous Comprehensive Evaluation of Theory Course		
Sr. No.	**Components for Continuous Comprehensive Evaluation**	**Marks Allotted**
1	LMS Test / Assignment on Problem solving through Computational Software / Tutorial / Group presentation on real life problem	20