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With CGPA 3.52

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शिवाजी विद्यापीठ, कोल्हापूर ४१६ ००४, महाराष्ट्र
दूरध्वनी - इपीबीएक्स - २०६०९०००, अभ्यासमंडळे विभाग : ०२३१- २६०९०९४. २६०९४८७
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SU/BOS/Sci & Tech/ 182 **Date: 10/06/2026**

The Director,
School of Engineering and Technology,
Shivaji University, Kolhapur.

Subject: Regarding revised syllabus of **B. Tech.** Part - IV (Sem VII & VIII) degree **Programme (Department of Technology)** under the Faculty of Science and Technology as per NEP 2020.

Sir/Madam,

With reference to the subject mentioned above, I am directed to inform you that the university authorities have accepted and granted approval to the revised syllabi, nature of question paper and equivalence of B. Tech. Part - IV (Sem VII & VIII) degree Programme under the Faculty of Science & Technology as per National Education Policy 2020 (NEP 2020).

Sr. No.	Course Syllabus
1	Civil Engineering
2	Mechanical Engineering
3	Computer Science and Technology
4	Chemical Engineering
5	Electronics and Telecommunication Engineering
6	Food Technology

This Syllabus, nature of question and equivalence shall be implemented from the academic year **2026-27** onwards. A soft copy containing the syllabus is attached herewith and it is available on university website **www.unishivaji.ac.in>Syllabus>Syllabus as per NEP-2020.**

The question papers on the pre-revised syllabi of above-mentioned course will be set for the examinations to be held in October/ November 2026 & March / April 2027. These chances are available for repeater students, if any

You are, therefore, requested to bring this to the notice of all students and teachers concerned.

Thanking you,

Yours faithfully,

Dy. Registrar

Copy to: for Information and necessary action

1	The I/c Dean, Faculty of Science & Technology	7	Appointment A & B Section
2	Director, Board of Examinations & Evaluation	8	Affiliation (T.1) (T.2) Section
3	The Chairperson, Respective Board of Studies	9	P.G.Admission Section,
4	Other Exam 4 Section,	10	P.G Seminar Section
5	Eligibility Section,	11	Computer Centre/ IT Cell
6	Internal Quality Assurance Cell (IQAC)		

Shivaji University
Vidyanagar, Kolhapur-416 004, Maharashtra

School of Engineering & Technology
(Formerly Department of Technology)

As per NEP2020 guidelines

Final Year B.Tech. (Chemical Engineering), Detailed Curriculum w.e.f. 2026-27

Shivaji University, Kolhapur
School of Engineering & Technology

Final Year B. Tech. (Chemical Engineering), Semester- VII

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.	Program Core Course	PCC411	Process Modelling &Simulation	03	-	02	05	04	30:70	00:50
2.	Program Core Course	PCC412	Piping & Instrumentation: Design & Drawing	03	-	02	05	04	30:70	50:00
3.	Program Core Course	PCC413	Transport Phenomena	03	-	-	03	03	30:70	00:00
4.	Program Elective Course	PEC411	Program Elective II	03	-	-	03	03	30:70	00:00
5.	Open Elective Course	OEC411	Open Elective- II	03	-	-	03	03	30:70	00:00
6.	Project Seminar Internship	PSI411	Major Project Phase-I	-	01	02	03	02	00:00	50:100
7.	Value Education Course	VEC411	Green Technology & Sustainability	01	-	-	01	01	-	50:00
8.	Project Seminar Internship	PSI412	MDM based Industry Internship *	One Month Duration*				03	-	50:50
							-	**23**	**500**	**400**
9.	Project Based Learning	PBL411	Major Project Lab		01	02	03	IE at Course in charge end		
			Total Hours	16	02	08	**26**	-	-	-

* The MDM based industry Internship to be completed during any winter/summer vacation slots 4th Semester onwards, before 7th Semester commencement.

Shivaji University, Kolhapur
School of Engineering & Technology

Final Year B. Tech. (Chemical Engineering), Semester- VIII

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.	Project Seminar Internship	PSI421	Industrial Internship & Major Project Phase-II	Entire Semester at Industry				10	-	150:200
2.	Program Elective Course [SWAYAM (NPTEL) or any other MOOCs] or Online	PEC421	Program Elective –III (Online)*	03	-	-	03	03	30:70	00:00
3.		PEC422	Program Elective –IV (Online)*	03	-	-	03	03	30:70	00:00
4.	Indian Knowledge Systems	IKS421	Program Specific IKS(Online)*	02	-	-	02	02	30:70	00:00
5.	Project Seminar Internship	PSI424	Plant Design & Case Studies (Online)*	01	-	-	01	01	-	50:50
6.	Value Education Course	VEC421	Professional Ethics (Online)*	01	-	-	01	01	-	50:00
7.	Project Based Learning	PBL421	MDM based Mini Project**	-	-	-	-	02	-	50:50
				-	**-**	**-**	**-**	**22**	**300**	**600**
			Total Hours (Other than Internship)	**10**	**00**	**00**	**10**	**-**	**-**	**-**

* Though the course is to be completed online either through course coordinator or via suitable MOOC if any, the ISE will be coordinated by the course in charge and the ESE will be through the University system.

** MDM based Mini Project to be completed during 4th Semester to 8th Semester.

Year, Program, Semester	Final Year B. Tech. (Chemical Engineering), Part IV, Semester VII							
Course Code	PCC411							
Course Category	Program Core Course							
Course title	**Process Modelling & Simulation (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)	PCC211, PCC212, BSC212, PCC212, PCC312, PCC313							
Course Rationale	This is a core subject of Chemical Engineering and the course provides students with a strong foundation in developing mathematical models based on physical laws such as mass, energy, and momentum balances. It enables learners to translate real-life processes into mathematical representations using differential equations, algebraic equations, and numerical methods. Through simulation, students can predict system behaviour under various operating conditions, perform sensitivity analysis, and evaluate alternative design or control strategies.							
Course Objectives	The course teacher will ensure to: 1. Derive mathematical models using conservation laws. 2. Formulate steady-state and dynamic process models. 3. Apply numerical methods for model solutions. 4. Demonstrate process simulation using computational software. 5. Analyse and optimize process performance results. 6. Interpret simulation data for process improvement.							
Course Outcomes	After completing the course, students will be able to: 1. Derive steady-state and dynamic process models. 2. Solve algebraic and differential equations numerically. 3. Simulate diverse chemical engineering unit operations. 4. Conduct sensitivity and parametric process analysis. 5. Utilize MATLAB, Aspen Plus, or Python. 6. Integrate simulation and optimization for design.							

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	1	-	-	-	-	-	-	-	-	1
CO2	3	3	2	1	-	-	-	-	-	-	-	1
CO3	2	3	1	2	1	-	-	-	-	-	-	1
CO4	2	2	2	2	3	-	-	-	-	-	-	1
CO5	2	3	3	2	2	1	1	-	-	-	1	1
CO6	1	1	1	2	2	2	1	-	-	-	-	-

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

Unit No.	Course Content	Hours
I	Use and scope of mathematical modelling, Principles of model formulation, Models and their classification, Degree-of-freedom analysis, Selection of design variables. Fundamental Laws and Review of numerical techniques, Equations of continuity, energy, momentum, and state	**06**
II	Review of thermodynamic correlations for the estimation of physical properties e.g. phase equilibria, bubble and dew points, Review of numerical techniques: Iterative methods, solution of linear simultaneous algebraic equations, numerical solution of integral and differential equations.	**06**
III	Basic models of flow system, Basic models of mixing systems, Basic models of simultaneous heat and mass transfer. Modelling of Specific Systems: constant volume CSTRS, Gas phase pressurized CSTR, non-isothermal CSTR, single component vaporizer, batch reactor, Plug flow reactor, reactor with mass transfer, ideal binary distillation column.	**10**
IV	Mathematical modelling of Shell and Tube Heat Exchanger, Double pipe heat exchanger, Multiple effect evaporator system. Analysis and modelling of evaporators using Newton Raphson's method (without boiling point rise), Modelling of multiple effect evaporators with boiling point rise.	**07**
V	Introduction and use of process simulation soft wares for flow sheet simulation. Tools of simulation, Case studies: VLE dew point, bubble point calculations, binary distillation column, counter current heat exchanger.	**06**
VI	Model Validation and Process Optimization Model validation and comparison with experimental data, Sensitivity analysis and process optimization basics, Dynamic simulation and control loop response	**04**
Text Books		
1.	Lubyen, W. L. (1989). Process Modeling, Simulation and Control for Chemical Engineers. McGrawHill, New York.	
2.	Mickley, H. S., Sherwood, T. S., & Reed, C. E. (2002). Application of Mathematical Modeling in Chemical Engineering. Tata-McGraw-Hill, New Delhi.	
Reference Books		
1.	Balu, K. & Padmanabhan, K. (2007). Modeling and analysis of Chemical Engineering processes. International private limited.	
2.	Turton, R., Bailie. R.C., Whiting, W.B., & Shaeiwitz, J.A. (2018). Analysis, Synthesis, and Design of Chemical Processes (5th ed.). Pearson.	
3.	Biegler. L.T., Grossmann, I.E., & Westerberg, A.W. (2011). Systematic Methods of Chemical Process Design (3rd ed.). Prentice Hall.	

Year, Program, Semester	Final Year B. Tech. (Chemical Engineering), Part IV, Semester VII							
Course Code	PCC411							
Course Category	Program Core Course							
Course title	**Process Modelling & Simulation (Laboratory)**							
Teaching Scheme and Credits	**L**	**T**	**P**	**Total Contact Hours**		**Total Credits**		
	-	-	02	02		01		
Evaluation Scheme	**ISE**	**ESE**		**IOE**	**IPE**	**EOE**	**EPE**	**Total**
	-	-		-	-	-	50	50
Pre-requisites (if any)	PCC211, PCC212, BSC212, PCC212, PCC312, PCC313							
Course Rationale	This is a core Chemical Engineering laboratory course and is essential for understanding of modelling & simulation techniques of chemical processes and to gain skills for use of process simulators.							
Course Objectives	The course teacher will: 1. To provide practical exposure in developing mathematical models for chemical process systems. 2. To train students in implementing steady-state and dynamic simulations using computational tools. 3. To develop skills in solving process equations using numerical methods and software platforms. 4. To enable students to analyze, interpret, and validate simulation results for process improvement.							
Course Outcomes	Upon completion of this course, student should be able to: 1. Develop and implement mathematical models for basic chemical engineering systems using conservation principles. 2. Perform steady-state and dynamic simulations using tools such as MATLAB, Python, or Aspen Plus/HYSYS. 3. Apply numerical methods within simulation platforms to solve algebraic and differential equations. 4. Analyze simulation outputs to evaluate process behaviour, validate models, and suggest process improvements.							

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	1	1	2	-	-	-	-	-	-	1
CO2	2	2	2	2	3	-	-	-	1	-	-	1
CO3	2	3	1	2	3	-	-	-	-	-	-	1
CO4	2	3	3	2	2	1	1	-	1	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.	**List of Experiments**	**Hours**
1.	Estimation of Thermodynamic properties and Vapour liquid Equilibria	**02**
2.	Mass and Energy balances	**02**
3.	Simulation of a pump	**02**
4.	Design & Simulation of a heat exchanger	**02**
5.	Design & Simulation of distillation column	**02**
6.	Design & Simulation of an evaporator	**02**
7.	Simulation of a flow sheet	**02**
8.	Optimization of process parameters in a flow sheet	**02**
9.	Simulation of an absorber	**02**
10.	Design of reactors	**02**
11.	Estimation of Thermodynamic properties and Vapour liquid Equilibria	**02**
Suggested Text Books/ Reference Books/Manual		
1.	Lubyen, W. L. (1989). Process Modeling, Simulation and Control for Chemical Engineers. McGrawHill, New York.	
2.	Mickley, H. S., Sherwood, T. S., & Reed, C. E. (2002). Application of Mathematical Modeling in Chemical Engineering. Tata-McGraw-Hill, New Delhi.	
3.	Balu, K. & Padmanabhan, K. (2007). Modeling and analysis of Chemical Engineering processes. International private limited.	

Year, Program, Semester	Final Year B. Tech. (Chemical Engineering), Part IV, Semester VII							
Course Code	PCC412							
Course Category	Program Core Course							
Course title	**Piping & Instrumentation: Design & Drawing (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)	ESC321, PCC322							
Course Rationale	Piping and instrumentation are the nervous system of a process plant, connecting equipment, sensors, and control systems. This course develops the ability to design, interpret, and analyse piping layouts and P& ID diagrams used in process industries. It emphasizes standards, safety codes, instrumentation selection, and drawing conventions, enabling students to bridge the gap between process design and plant implementation.							
Course Objectives	The course teacher will ensure to: 1. Explain piping and instrumentation design principles. 2. Detail P&ID symbols, codes, and standards. 3. Illustrate piping components and material selection. 4. Analyse layout, routing, and stress factors. 5. Interpret process diagram instrumentation and controls. 6. Demonstrate CAD tools for plant drawings.							
Course Outcomes	After completing the course, students will be able to: 1. Explain basics of piping and instrumentation design. 2. Identify piping components, materials, and fittings. 3. Interpret symbols, standards, and codes in P& ID. 4. Develop process and utility piping layouts. 5. Evaluate design for safety, pressure, and flexibility. 6. Prepare and read P& ID drawings using CAD tools.							

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	1	-	1	1	-	-	-	1	-	1
CO2	3	3	2	1	2	-	-	-	-	-	-	1
CO3	2	3	3	2	3	-	1	-	-	1	1	2
CO4	1	2	3	3	3	1	1	1	-	1	2	2
CO5	1	2	3	3	3	1	1	-	-	-	1	1
CO6	1	1	1	2	2	2	1	-	-	-	-	1

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

Unit No.	Course Content	Hours
I	Introduction to Piping Design, Role of piping in process industries, Classification and functions of piping systems, Terminology, codes (ASME, ANSI, ISO), and standards, Overview of P&IDs and process flow diagrams (PFDs)	**05**
II	Piping Components and Materials, Pipes, fittings, flanges, gaskets, valves, Material selection: corrosion, temperature, pressure factors, Standard dimensions and schedules, Fabrication and joining methods	**07**
III	Layout and Design Considerations, Plant layout principles and routing guidelines, Equipment spacing, accessibility, and maintenance, Thermal expansion, stress, and flexibility analysis, Support systems and pipe stress analysis basics	**07**
IV	Instrumentation and Control Elements, Measurement of process variables: flow, pressure, temperature, level, Control valves, actuators, transmitters, indicators, Process control loops and signal types, Instrumentation selection and placement	**07**
V	P&ID Standards and Drafting, ISA and ISO P&ID symbols, Line numbering, tagging, and legend sheets, Preparation and interpretation of P&ID drawings, Case studies: P&ID for reactor and distillation systems	**06**
VI	Software and Safety Integration, CAD tools for piping design (AutoCAD Plant 3D / Smart Plant P&ID), Integration of safety and control interlocks, Documentation, revision control, and plant validation, Digital twins and 3D visualization of P&IDs Focus: Evaluation and creation (L5–L6; SOLO – Extended Abstract)	**07**
Reference Books		
1.	Nayyar, M.L. (2019). Piping Handbook (8th ed.), McGraw-Hill, New York.	
2.	Gupta, S.K. (2011). Piping Design for Process Plants. Wiley Eastern, New Delhi.	
3.	Becht, G. (2016). Process Piping: The Complete Guide to ASME B31.3. Becht Engineering Co.	
4.	Mehta, N.P. (2017). Piping and Instrumentation Drawing Practice. Jaico Publishing, Mumbai.	
5.	Nandakumar, K., & Kannan, R. (2020). Instrumentation and Process Control. PHI Learning, New Delhi.	

Year, Program, Semester	Final Year B. Tech. (Chemical Engineering), Part IV, Semester VII							
Course Code	PCC412							
Course Category	Program Core Course							
Course title	**Piping & Instrumentation: Design & Drawing (Laboratory)**							
Teaching Scheme and Credits	**L**	**T**	**P**	**Total Contact Hours**		**Total Credits**		
	-	-	02	02		01		
Evaluation Scheme	**ISE**	**ESE**		**IOE**	**IPE**	**EOE**	**EPE**	**Total**
	-	-		-	50	-	-	50
Pre-requisites (if any)	ESC321, PCC322							
Course Rationale	This lab course offers hands-on experience in preparing and interpreting Piping and Instrumentation Diagrams (P&IDs) using both manual and computer-aided design methods. Students learn to apply industrial standards and safety considerations in designing process layouts and control loops.							
Course Objectives	The course teacher will: 1. Demonstrate P&ID symbols and industry standards. 2. Explain piping layout drawings and conventions. 3. Guide CAD software for plant layouts. 4. Illustrate instrumentation and control symbol applications.							
Course Outcomes	Upon completion of this course, student should be able to: 1. Use P & ID symbols and standard conventions. 2. Prepare piping layouts for unit operations. 3. Draw and interpret process and utility P&IDs. 4. Simulate instrumentation and control loops.							

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	1	-	1	1	-	-	-	1	-	1
CO2	3	3	2	1	2	-	-	-	-	-	-	1
CO3	2	3	3	2	3	-	1	-	-	1	1	2
CO4	1	2	3	3	3	2	3	1	1	2	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.	**List of Experiments**	**Hours**
1.	Introduction to P&ID symbols (ISA / ISO standards).	**02**
2.	Drawing of basic process flow diagrams (PFDs).	**02**
3.	Preparation of a simple water flow system P& ID.	**02**
4.	Drawing and detailing of pump and pipeline connections.	**02**
5.	Reactor and heat exchanger piping layout design.	**02**
6.	P&ID of distillation column system.	**02**
7.	Instrumentation diagram for pressure and temperature control loops.	**02**
8.	P&ID for utility systems (cooling water / steam).	**02**
9.	CAD-based drawing using AutoCAD Plant 3D / Smart Plant P&ID.	**02**
10.	Integration of safety interlocks and alarms.	**02**
11.	Case study on real industrial P&ID.	**02**
12.	Mini-project: complete process system drawing and presentation.	**02**
Suggested Text Books/ Reference Books/Manual		
1.	Nayyar, M.L. (2019). Piping Handbook. McGraw-Hill, New York.	
2.	Gupta, S.K. (2011). Piping Design for Process Plants. Wiley Eastern, New Delhi.	
3.	Nandakumar, K., & Kannan, R. (2020). Instrumentation and Process Control. PHI Learning, New Delhi.	
4.	Mehta, N.P. (2017). Piping and Instrumentation Drawing Practice. Jaico Publishing, Mumbai.	

Year, Program, Semester	Final Year B. Tech. (Chemical Engineering), Part IV, Semester VII							
Course Code	PCC413							
Course Category	Program Core Course							
Course title	**Transport Phenomena (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)	BSC112, BSC122, PCC211, PCC221, PCC311, PCC321							
Course Rationale	The purpose of this course is to introduce and make aware the students about different flow patterns for various types of geometries. It is the application of common principles to the study of mass transfer, heat transfer, and fluid mechanics.							
Course Objectives	The course teacher will ensure to: 1. Summarize vector and tensor coordinate operations. 2. Describe flow terms for various geometries. 3. Discuss transport equations for isothermal systems. 4. Illustrate isothermal mass and energy balances. 5. Outline interphase transport in non-isothermal systems. 6. Detail multi-phase and reactive mass transfer.							
Course Outcomes	After completing the course, students will be able to: 1. Apply vector and tensor coordinate operations. 2. Analyse flow regimes through various geometries. 3. Solve transport equations for isothermal systems. 4. Derive isothermal mass and energy balances. 5. Explain interphase transport in non-isothermal systems. 6. Evaluate multi-phase and reactive mass transfer.							

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	-	-	-	-	-	-	-	-	1
CO2	3	2	2	-	-	-	-	-	-	-	-	1
CO3	3	2	2	-	-	-	-	-	-	-	-	1
CO4	3	2	2	-	-	-	-	-	-	-	-	1
CO5	3	2	2	-	-	-	-	-	-	-	-	1
CO6	3	2	1	-	2	-	-	-	-	-	-	1

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

Unit No.	Course Content	Hours
I	**Vector and Tensor analysis:** Vector Operation from a geometrical view point & in terms of component, Tensor operation in terms of component. Vector and tensor: differential operations and integral theorems, algebra in curvilinear coordinate. Curvilinear Coordinates: Vector & Tensor algebra, differential and integral Operation.	**05**
II	**Equations of Change and Velocity distribution**: Viscosity and the mechanism of momentum transport, Newton's law of viscosity, non-Newtonian fluids, pressure & temperature dependence of viscosity, estimation of viscosity from critical properties, Velocity distribution in laminar flow, Shell momentum balances, boundary conditions, flow of a falling film, flow through a circular tube, flow through annular, creeping flow along a solid sphere.	**07**
III	**Equations of change and Interphase transport for isothermal systems**: Time derivatives and vector notations, the equation of continuity, the equation of motion, the equations of change in curvilinear, co-ordinates, Inter phase transport in isothermal systems, Definition of friction factors, friction factors for flow in tubes, friction factors for flow around spheres, friction factors for packed column.	**07**
IV	**Macroscopic balances for isothermal systems**: The Macroscopic mass balance, the macroscopic mechanical energy balances, estimation of friction loss, Thermal conductivity and the mechanism of energy transport, Fourier's law of heat conduction, temperature and pressure dependence of thermal conductivity in gases and liquids, theory of thermal conductivity of gases at low density.	**07**
V	**Temperature distributions in solids and in laminar flow:** Shell energy balance, boundary conditions, Heat conduction with an electrical heat source, Heat conduction in cooling fins, heat conduction with exothermic reactions, Interphase Transport in Non isothermal Systems, Definition of heat transfer coefficients, Heat transfer coefficient for forced convection in tubes, Heat transfer coefficient for forced convection around submerged objects and through packed beds, Heat transfer coefficient for free convection, Heat transfer coefficient for condensation of pure vapors.	**07**
VI	**Diffusivity and the mechanism of mass transports:** Definitions of concentrations, velocities & mass fluxes, Fick's law of diffusion, Temperature & pressure dependence of mass diffusivity, Maxwell's law of diffusion. Concentration distributions in solids and in a laminar flow, Shell mass balance, boundary conditions, diffusion through a stagnant gas film, Diffusion with heterogeneous chemical reaction, Diffusion with homogeneous chemical reaction, Diffusion into a falling liquid film.	**06**
Text Books		
1.	Bird, R. B., Stewart, W. E., & Lightfoot, E. N. (2007). Transport Phenomena (2nd ed.). Wiley.	
2.	Geankoplis C. J. (2003). Transport Processes and Separation Process Principles (4th ed.). Prentice Hall India.	
3.	Deen, W. M. (2012). Analysis of Transport Phenomena (2nd ed.). Oxford University Press.	
4.	Welty, J. R., Wicks, C. E., Wilson, R. E., & Rorrer, G. L. (2011). Fundamentals of Momentum, Heat, and Mass Transfer (6th ed.). Wiley.	
Reference Books		

1.	Cussler, E. L. (2009). Diffusion: Mass Transfer in Fluid Systems (3rd ed.). Cambridge University Press.
2.	Slattery, J. C. (1999). Advanced Transport Phenomena: Fluid Mechanics and Convective Transport Processes. Cambridge University Press.
	Useful web links
1.	https://nptel.ac.in/courses/103105128
2.	https://archive.org/details/cftri.7494transportphenome0000rbyr/page/263/mode/1up

Year, Program, Semester	Final Year B. Tech. (Chemical Engineering), Part IV, Semester VII							
Course Code	PEC411.1							
Course Category	Program Elective Course							
Course title	**Program Elective-II: Petrochemical Technology (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)	PCC211, PCC221, PCC222, PCC311, PCC313							
Course Rationale	This course provides an overview of the petrochemical industry, its raw materials, and the processes used to transform crude oil and intermediate streams into finished products. Discuss generational change in the petrochemical industry. This course explores the potential of the petrochemical industry, focusing on the production of petrochemicals from various feedstocks.							
Course Objectives	The course teacher will ensure to: 1. Trace petrochemical history and future trends. 2. Explain first-generation petrochemical importance. 3. Detail second-generation production with flowsheets. 4. Describe plastic and polymer technologies 5. Illustrate detergent and explosive manufacturing. 6. Discuss industry challenges and opportunities.							
Course Outcomes	After completing the course, students will be able to: 1. Analyse petrochemical industry trends and prospects. 2. Evaluate first-generation feedstock industrial significance. 3. Explain primary petrochemical gas separation techniques. 4. Construct production flowsheets for downstream petrochemicals. 5. Compare polymer, surfactant, and explosive manufacturing. 6. Assess global petrochemical challenges and opportunities.							

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
CO2	3	2	1	-	-	-	2	-	-	-	-	1
CO3	3	2	1	-	-	-	2	-	-	-	-	1
CO4	3	2	1	-	-	-	2	-	-	-	-	1
CO5	3	2	-	-	-	-	2	-	-	-	-	1
CO6	3	2	-	-	-	-	1	-	-	-	-	1

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

Unit No.	Course Content	Hours
I	**Introduction:** History, Economics and future of petrochemicals, Energy crisis and petrochemical industry, Feedstocks for petrochemicals, Purification of gases, Sources and classification of petrochemicals.	**06**
II	**First generation petrochemicals:** Alkanes - C1, C2, C3, C4 petrochemicals, alkenes - C2, C3, C4, petrochemicals, alkynes -C2, C3, C4 petrochemicals, B-T-X aromatics, diene based petrochemicals.	**07**
III	**Second generation petrochemicals:** Synthesis gas, methanol, formaldehyde chloromethane, ethanol, acetaldehyde, acetic acid, acetic anhydride, isopropyl alcohol, ethylene oxide, propylene oxide, acetone, vinyl chloride, phenol, aniline and styrene.	**07**
IV	**Third generation petrochemicals:** Plastics, rubbers and fibres, olefinic polymers, polyethylene, polypropylene, polyisobutylene, diene polymers - polybutadiene, neoprene, polyisoprene, SBR, synthetic fibres.	**07**
V	**Miscellaneous petrochemicals:** Petroleum proteins, synthetic detergents, resin and rubber chemicals, explosives - TNT and RDX.	**06**
VI	**Challenges and opportunities of petrochemical industry:** Shortage of petroleum crude, Dependence on Foreign Countries, Price Hike, Exploration of New Reserves, Lack of Market-Determined Pricing System, Compatibility with refinery infrastructure.	**06**
Text Books		
1.	Bhaskara Rao, B.K. (2000). A Text on Petrochemicals. Khanna Publishers.	
2.	Maiti, S. (2002). Introduction to Petrochemicals (2nd ed.). Oxford and IBH Publishers.	
3.	Steines, H. (1961). Introduction to petrochemical Industry. Pergamon.	
4.	Hobson, G. D. & Pohl, W. (1975). Modern Petroleum Technology (4th ed.). Applied Science Publishers.	
Reference Books		
1.	Wells, M. (2002).Handbook of Petrochemicals and Processes (2nd ed.). Ash Gate Publishing Limited.	
2.	Matar, S. & Hatch, L. F. (2000). Chemistry of Petrochemical Processes (2nd ed.). Gulf Publishing Company.	
3.	Dryden C.E. (1993). Outlines of Chemical Technology (2nd ed.). Affiliated East-West Press.	
4.	Goldsten, R.F. & Waddams, A. L. (1967).The Petroleum Chemical Industry (3rd ed.). Spon Ltd.	
5.	Austin, G.T. (1986). Shreve's Chemical Process Industries (5th ed.). McGraw Hill.	
Useful web links		
1.	https://nptel.ac.in/courses/103107082	
2.	https://www.youtube.com/watch?v=AzDHCyboKqY	

Year, Program, Semester	Final Year B. Tech. (Chemical Engineering), Part IV, Semester VII						
Course Code	PEC411.2						
Course Category	Program Elective Course						
Course title	**Program Elective-II: Industrial Biotechnology (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)	PCC212, PCC224, PCC311, PCC312						
Course Rationale	Industrial biotechnology integrates biological science with process engineering to develop sustainable, efficient, and eco-friendly industrial products and processes. This course provides chemical engineering students with the knowledge of bioprocess principles, microbial technology, enzyme applications, and bioreactor design — enabling them to apply engineering analysis to biological production systems. It aims to cultivate interdisciplinary understanding, linking biochemistry, microbiology, and transport phenomena for industrial production of pharmaceuticals, biofuels, and fine chemicals, while emphasizing sustainability and green technology.						
Course Objectives	The course teacher will ensure to: 1. Illustrate fundamental principles of industrial biotechnology. 2. Detail industrial microbial and enzymatic systems. 3. Explain bioprocess design and operation principles. 4. Demonstrate fermentation and downstream processing techniques. 5. Evaluate biotechnology applications in chemical industries. 6. Discuss biosafety, bioethics, and sustainable practices.						
Course Outcomes	After completing the course, students will be able to: 1. Explain principles of industrial biotechnology. 2. Describe roles of microorganisms and enzymes. 3. Apply bioprocess and bioreactor principles. 4. Analyse fermentation and downstream operations. 5. Evaluate industrial biotechnological applications. 6. Discuss biosafety, ethics, and sustainability issues.						

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	-	-	-	1	2	2	-	1	-	1
CO2	3	3	2	1	2	-	2	-	-	-	-	1
CO3	2	3	3	2	3	1	2	-	-	1	1	2
CO4	1	2	3	3	3	1	3	-	-	1	2	2
CO5	1	2	3	3	3	2	3	1	1	2	2	3
CO6	-	1	1	-	1	3	3	3	1	3	1	3

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

Unit No.	Course Content	Hours
I	**Introduction to Industrial Biotechnology:** Scope and importance of biotechnology in industry, Biological vs. chemical process systems, Overview of metabolic pathways and product formation, Biotechnological production of fuels, chemicals, and materials	**05**
II	**Microbial and Enzyme Technology:** Industrially important microorganisms and strain improvement, Enzyme classification, kinetics, and applications, Immobilized enzymes: preparation, kinetics, and reactor types, Case studies: enzyme catalysis in food and chemical industries	**07**
III	**Bioprocess Engineering Principles:** Stoichiometry and kinetics of microbial growth, Mass and energy balances in bioprocesses, Bioreactor types and configurations (batch, fed-batch, continuous), Scale-up principles and process control in bioreactors	**07**
IV	**Industrial Fermentation Processes:** Fermentation systems for ethanol, citric acid, antibiotics, amino acids, and enzymes, Media formulation and sterilization, Process optimization and monitoring, Role of aeration, agitation, and substrate utilization	**07**
V	**Downstream Processing:** Cell disruption, solid–liquid separation, Filtration, centrifugation, extraction, adsorption, chromatography, Product purification, concentration, and drying, Process integration and recovery yield optimization	**07**
VI	**Biosafety, Bioethics, and Sustainable Biotechnology:** Biosafety levels and containment, Ethical considerations in genetic modification, Regulatory aspects and GMP standards, Circular bio-economy and sustainable bio-industrial systems	**06**
Reference Books		
1.	Shuler, M.L., & Kargi, F. (2017). Bioprocess Engineering: Basic Concepts (3rd ed.). Pearson Education, New York.	
2.	Doran, P.M. (2013). Bioprocess Engineering Principles (2nd ed.). Academic Press, London.	
3.	Crueger, W., & Crueger, A. (2017). Biotechnology: A Textbook of Industrial Microbiology. Panima Publishing, New Delhi.	
4.	Stanbury, P.F., Whitaker, A., & Hall, S.J. (2016). Principles of Fermentation Technology (3rd ed.). Elsevier, Oxford.	
5.	Moo-Young, M. (2011). Comprehensive Biotechnology. Elsevier, Amsterdam.	

Year, Program, Semester	Final Year B. Tech. (Chemical Engineering), Part IV, Semester VII							
Course Code	PEC411.3							
Course Category	Program Elective Course							
Course title	**Program Elective-II: Polymer Technology (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)	BCC111, BSC211, ESC211, PCC313							
Course Rationale	This course will help students to learn about polymers, one of the most significant modern materials. The course will introduce different types of polymers and methods of polymerization. It will also help them to understand the role of additives in the polymers and uses of different polymers.							
Course Objectives	The course teacher will ensure to: 1. Explain polymerization types and reaction mechanisms. 2. Detail polymerization kinetics and reactor design. 3. Analyse polymer structure-property relationship principles. 4. Demonstrate polymer processing techniques and equipment. 5. Illustrate polymer characterization and testing methods. 6. Evaluate polymer product applications and sustainability.							
Course Outcomes	After completing the course, students will be able to: 1. Explain polymerization mechanisms and polymer types. 2. Analyse kinetics and reactor design for polymerization. 3. Describe structure–property relationships of polymers. 4. Explain polymer processing and fabrication techniques. 5. Apply characterization methods for quality evaluation. 6. Discuss polymer applications and environmental impact.							

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	1	-	1	1	-	-	-	1	-	1
CO2	3	3	2	1	2	-	-	-	-	-	-	1
CO3	2	3	3	2	3	-	1	-	-	1	1	2
CO4	1	2	3	3	3	1	1	1	-	1	2	2
CO5	1	2	3	3	3	2	3	1	1	2	2	3
CO6	-	1	1	-	1	3	3	3	1	3	1	3

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

Unit No.	Course Content	Hours
I	**Introduction to Polymers:** Definitions: polymer& macromolecule, monomer, functionality, average functionality, copolymer, polymer Blend, plastic and resin. Classification of polymers: based on source, structure, applications, thermal behaviour, Brief study of i) Natural rubber ii) Shellac iii) Rosin iv) Cellulose v) Proteins	**06**
II	**Polymer Properties and Rheology:** Concept of average molecular weight of polymers, molecular weight distribution, poly disparity index. Thermal, mechanical, and electrical properties, Glass transition and melting behavior, Rheology of polymer melts and solutions	**06**
III	**Polymerization Mechanism and kinetics:** Addition or chain polymerization and step growth or condensation polymerization. Free radical, Ionic addition Polymerization, Coordination polymerization, polymerization kinetics and rate equations, Reactor design for polymer production (batch, CSTR, tubular)	**08**
IV	**Polymer Processing Techniques:** Compression and transfer moulding, Injection moulding, Extrusion, Blow moulding, Calendaring, Laminating and pultrusion	**06**
V	**Polymer Characterization and Testing:** Determination of average molecular weights, end group analysis, osmometry, light scattering techniques, viscometer, and Gel permeation chromatography, Thermal analysis (DSC, TGA),Mechanical testing (tensile, impact, hardness),Spectroscopic methods (FTIR, NMR)	**07**
VI	**Applications, Recycling, and Sustainability:** Commodity, engineering, and specialty polymers, Biodegradable and bio-based polymers, Polymer recycling and waste management	**06**

Reference Books

1.	Billmeyer, F.W. (2007). Textbook of Polymer Science (3rd ed.). Wiley, New York.
2.	Gowariker, V.R., Viswanathan, N.V., & Jayadev, S. (2015). Polymer Science. New Age International, New Delhi.
3.	Seymour, R.B., & Carraher, C.E. (2012). Introduction to Polymer Chemistry. CRC Press, Boca Raton.
4.	Fried, J.R. (2014). Polymer Science and Technology (3rd ed.). Pearson Education, London.
5.	Odian, G. (2004). Principles of Polymerization (4th ed.). Wiley, New York.
6.	Brydson J.A. (1975). Plastic materials. Newnes-Butterwarths.

Year, Program, Semester	Final Year B. Tech. (Chemical Engineering), Part IV, Semester VII						
Course Code	PEC411.4						
Course Category	Program Elective Course						
Course title	**Program Elective-II: Food Process Technology (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)	PCC221, PCC212, PCC311						
Course Rationale	Food Process Technology applies chemical engineering principles to the transformation, preservation, packaging, and distribution of food products. Chemical engineers play a key role in designing food processing operations involving heat transfer, mass transfer, reaction kinetics, separations, and process control. This course provides students with a scientific and engineering understanding of major food processing operations, quality and safety considerations, and emerging sustainable food technologies. It prepares graduates for employment in food, beverage, nutraceutical, and allied process industries, as well as for advanced studies and research.						
Course Objectives	The course teacher will ensure to: 1. Explain food composition and preservation principles. 2. Apply engineering concepts to food operations. 3. Interpret microbial and chemical food kinetics. 4. Analyse thermal and non-thermal food technologies. 5. Evaluate food quality and safety aspects. 6. Integrate unit operations into process schemes.						
Course Outcomes	After completing the course, students will be able to: 1. Describe physical, chemical, and biological properties of foods. 2. Apply material and energy balances to food processing systems. 3. Analyse kinetics of microbial inactivation and quality degradation. 4. Analyse major thermal and non-thermal food processing operations. 5. Interpret the production of different food products 6. Evaluate food quality, safety, and packaging requirements.						

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	1	1	-	1	1	-	-	1	-	2
CO2	3	3	2	1	1	-	1	-	-	1	-	2
CO3	3	3	2	2	1	-	1	-	-	1	-	2
CO4	3	3	2	2	2	1	1	-	-	1	-	2
CO5	3	2	2	1	1	1	1	-	-	1	1	2
CO6	2	2	2	1	1	3	2	1	-	1	-	2

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

Unit No.	Course Content	Hours
I	**Introduction to Food Process Technology:** Scope and importance of food processing, Food as a biological material, Major food constituents: water, carbohydrates, proteins, fats, vitamins, minerals, Physical and chemical properties of foods, Food spoilage mechanisms	**06**
II	**Food Preservation Principles:** Preservation by temperature control, Preservation by moisture control, Preservation by chemicals and fermentation, Hurdle technology, Shelf-life concept	**06**
III	**Kinetics of Food Deterioration and Microbial Inactivation:** Reaction order and rate constants, Thermal death time (TDT) curves, D-value, Z-value, F-value, Nutrient degradation kinetics, Modeling of shelf life	**07**
IV	**Thermal and Non-Thermal Food Processing Operations:** Blanching, Pasteurization, Sterilization and canning, Freezing and drying, High-pressure processing (HPP), Pulsed electric fields (PEF), Ultrasound processing	**08**
V	**Production and Utilization of Food Products:** Cereal grains; pulses; vegetables; fruits, Spices; fats and oils; bakery; confectionery, Chocolate products; soft and alcoholic beverages, Dairy products; meat; poultry and fish products	**06**
VI	**Food Quality, Packaging & Process Integration:** Food quality attributes, Food safety: HACCP and GMP, Packaging materials and methods, Storage and transportation, Integrated food processing plant flow diagram	**06**
Text Books		
1.	Berk, Z. (2018). Food Process Engineering and Technology (3rd ed.). Academic Press.	
2.	Singh, R. P., & Heldman, D. R. (2014). Introduction to Food Engineering (5th ed.). Academic Press.	
3.	Fellows, P. J. (2017). Food Processing Technology: Principles and Practice (4th ed.). Woodhead Publishing.	
4.	Barbosa-Canovas, G. V., Juliano, P., Peleg, M., & Sablani, S. S. (2018). Food Engineering Operations. Springer.	
5.	Heldman, D. R., & Lund, D. B. (2007). Handbook of Food Engineering (2nd ed.). CRC Press.	
Reference Books		
1.	Sahay, K. M., & Singh, K. K. (2004). Unit Operations of Agricultural Processing. Vikas Publishing House.	
2.	Fennema, O. R. (1996). Food Chemistry (3rd ed.). CRC Press.	
3.	Macrae, R., Robinson, R. K., & Sadler, M. J. (1993). Encyclopedia of Food Science, Food Technology and Nutrition. Vol. 8. Academic Press.	

Year, Program, Semester	Final Year B. Tech. (Chemical Engineering), Part IV, Semester VII							
Course Code	PEC411.5							
Course Category	Program Elective Course							
Course title	**Program Elective-II: Biochemical Engineering (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)	BSC212, PCC212, PCC224, PCC311, PCC312							
Course Rationale	Biochemical Engineering integrates chemical engineering principles with biological systems to design and operate processes for producing pharmaceuticals, enzymes, biofuels, food ingredients, and other bioproducts. Modern chemical engineers increasingly work at the interface of biology and engineering. This course equips students with the capability to analyze biological reaction systems, design bioreactors, evaluate fermentation performance, and integrate upstream and downstream operations in a bioprocess plant. The course bridges fundamental biochemical concepts with scalable engineering practice, preparing graduates for careers in bioprocess industries, research, and advanced studies.							
Course Objectives	The course teacher will ensure to: 1. Explain fundamental principles governing biochemical reactions and microbial growth. 2. Apply material and energy balances to biological systems. 3. Analyze kinetics of enzymatic and microbial processes. 4. Design and evaluate bioreactors for different modes of operation. 5. Assess mass transfer and mixing phenomena in bioprocesses. 6. Integrate upstream and downstream process schemes.							
Course Outcomes	After completing the course, students will be able to: 1. Describe biochemical reactions and cellular metabolism. 2. Perform bioprocess mass and energy balances. 3. Analyze enzyme and microbial growth kinetics. 4. Design batch, fed-batch, and continuous bioreactors. 5. Evaluate bioreactor mass transfer and mixing. 6. Propose integrated upstream and downstream processes.							

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	1	1	-	-	1	-	-	1	-	2
CO2	3	3	2	1	1	-	1	-	-	1	-	2
CO3	3	3	2	2	1	-	-	-	-	1	-	2
CO4	3	2	3	2	2	1	1	-	1	1	1	2
CO5	3	3	2	2	2	1	1	-	-	1	-	2
CO6	3	2	3	3	2	2	2	1	1	2	2	2

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

Unit No.	Course Content	Hours
I	**Introduction to Biochemical Engineering :** Role of biochemical engineering in modern industry, Living cells vs chemical catalysts, Cell structure and functions (prokaryotes & eukaryotes), Basic metabolic pathways: catabolism, anabolism, Stoichiometry of cell growth and product formation	**06**
II	**Biochemical Thermodynamics & Material Balances:** Thermodynamics of biological reactions and their significance in understanding energy changes in living systems; Gibbs free energy concepts and feasibility of bio-reactions; yield coefficients, growth yield, and maintenance energy requirements; material balances for batch and continuous bioprocesses; application of elemental balance approach for fermentation systems to estimate biomass and product formation.	**06**
III	**Enzyme Kinetics and Immobilized Enzymes**: Fundamentals of enzyme-catalysed reactions and their industrial relevance; Michaelis–Menten kinetics and interpretation of kinetic parameters; substrate inhibition and product inhibition effects on reaction rate; influence of temperature and pH on enzyme activity and stability; immobilized enzymes including methods of immobilization, kinetic behavior, advantages, limitations, and industrial applications.	**07**
IV	**Microbial Growth Kinetics and Fermentation Models:** Microbial growth curve and different growth phases in batch culture; Monod model for microbial growth kinetics; Logistic and Contois models for growth prediction; relationships among biomass, substrate consumption, and product formation; comparison of structured and unstructured models for fermentation process analysis and design.	**08**
V	**Bioreactors–Design and Operation:** Classification and working principles of different types of bioreactors; operation of batch, fed-batch, and continuous reactors; sterilization methods for bioreactors and associated equipment; scale-up criteria and challenges in bioprocess industries; evaluation of productivity and performance parameters for efficient reactor operation.	**06**
VI	**Transport Phenomena & Downstream Processing:** Oxygen transfer in bioreactors and estimation of volumetric mass transfer coefficient (kLa); role of mixing and agitation in maintaining uniform culture conditions; heat transfer considerations in bioreactor systems; overview of downstream processing steps; techniques for	**06**

	cell separation, product recovery, and purification; development of integrated bioprocess flow diagrams for complete production systems.	
Text Books		
1.	Shuler, M. L., & Kargi, F. (2002). Bioprocess Engineering: Basic Concepts (2nd ed.). Prentice Hall.	
2.	Stanbury, P. F., Whitaker, A., & Hall, S. J. (2017). Principles of Fermentation Technology (3rd ed.). Butterworth-Heinemann.	
3.	Crueger, W., & Crueger, A. (2000). Biotechnology: A Textbook of Industrial Microbiology and Biotechnology (2nd ed.). Sinauer Associates.	
4.	Doble, M., & Sathyanarayana N. (2007). Biochemical Engineering, Gummai, Prentice Hall.	
Reference Books		
1.	Doran, P. M. (2013). Bioprocess Engineering Principles (2nd ed.). Academic Press.	
2.	Aiba, S., Humphrey, A. E., & Millis, N. F. (1973). Biochemical Engineering. Academic Press.	
3.	Prescott, S. C., & Dunn, C. G. (2004). Industrial Microbiology (4th ed.). CBS Publishers.	
4.	Bailey, J. E., & Ollis, D. F. (1986). Biochemical Engineering Fundamentals (2nd ed.). McGraw-Hill.	

Year, Program, Semester	Final Year B. Tech. (Chemical Engineering), Part IV, Semester VII						
Course Code	PEC411.6						
Course Category	Program Elective Course						
Course title	**Program Elective-II: Advanced Separation Techniques (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)	PCC311 ,PCC321 , PCC413						
Course Rationale	This course builds upon fundamental mass transfer concepts to introduce advanced and emerging separation techniques used in modern chemical, biochemical, and environmental industries. It focuses on membrane processes, adsorption, chromatographic techniques, supercritical fluid extraction, and bio-separations, enabling students to understand, select, and design appropriate separation systems. The course also aligns with sustainable and efficient processing needs in industries such as pharmaceuticals, food, and wastewater treatment.						
Course Objectives	The course teacher will ensure to: 1. Explain principles and classify advanced techniques. 2. Demonstrate mass transfer in complex systems. 3. Teach membrane process design and fundamentals. 4. Illustrate industrial adsorption and chromatography applications. 5. Critique supercritical and electric field-assisted separations. 6. Outline downstream processing for biochemical industries.						
Course Outcomes	After completing the course, students will be able to: 1. Classify advanced separation techniques and principles. 2. Apply mass transfer to separation processes. 3. Design membrane systems for specific applications. 4. Analyze adsorption, chromatography, and ion-exchange. 5. Evaluate SFE, electrophoresis, and cryogenic separations. 6. Apply downstream processing in biochemical industries.						

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	-	-	-	-	-	-	-	1	-	1
CO2	3	3	1	1	1	-	-	-	-	1	-	1
CO3	3	2	3	1	2	-	1	-	-	1	1	1
CO4	3	3	2	2	1	-	1	-	-	1	-	1
CO5	3	2	2	2	2	1	1	-	-	1	-	1
CO6	3	2	2	1	1	1	2	1	1	2	-	1

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

Unit No.	Course Content	Hours
I	**Introduction:** Fundamentals of separation processes and basic concepts. Introduction to separation techniques and classifications, separation factor. Review of basic mass-transfer concepts: diffusion coefficients, diffusion in fluids and porous solids, steady-state and unsteady state mass transfer	**06**
II	**Membrane based Separation processes**: Definition of a membrane, classification of membrane processes and membrane modules. Types of Membrane materials, phase inversion membranes, preparation technique for immersion precipitation, preparation technique for composite membranes, Synthesis and characterization of membranes, driving forces in membrane separation processes, Concept of concentration polarization and membrane fouling, pressure driven membrane processes and their industrial applications	**07**
III	**Chromatographic separation processes, adsorption and Ion exchange, cryogenic gas separation:** Basic concept of chromatography, phenomena and characterization. Various chromatography options. Typical chromatographic separation systems for preparative chromatography. Applications of chromatography in enzymes and other Industrial separations. Adsorption and ion exchange equilibria, equilibrium and kinetics, Various isotherms. Contact filtration, design of fixed bed adsorber including breakthrough curve. Pressure swing and vacuum swing adsorption. Introduction to the cryogenic gas separation and purification systems, separation of air, hydrogen and helium, gas purification methods.	**06**
IV	**Electric field assisted separation processes:** Introduction, electro dialysis, Process parameters, membranes for electro dialysis, applications, Electrophoretic Separation Methods, Forces in Electrophoresis, Gel membrane and paper electrophoresis, Zonal electrophoresis	**06**
V	**Supercritical fluid separation processes**: Working Principal, Advantage & Disadvantages of supercritical solvents over conventional liquid solvents, Advantage & Disadvantages of supercritical extraction over liquid- liquid extraction, Decaffeination, ROSE process, Commercial applications of supercritical extraction.	**07**

VI	**Separation processes in biochemical industry**: Introduction. Initial product harvest and concentration: centrifugation, Filtration, Selection of cell separation Unit operation, Cell disruption, protein refolding. Initial purification: Precipitation, Extraction, Adsorption, Membrane processes. Final Purification and product formulation, Chromatography, Lyophilization and drying. Integration of fermentation and downstream processing operations.	**07**
Text Books		
1.	Nath, K. (2008). Membrane separation Processes (2nd ed.). PHI Pvt. Ltd	
2.	Treybal, R.E. (1998). Mass Transfer Operations (3rd ed.). McGraw Hill.	
3.	Scott RTW. (1992). Liquid Chromatography Column Theory, Wiley.	
4.	Hoffman, E.J. (2003). Membrane Separation Technology (1st ed.). Gulf Professional Publishing	
5.	Winston Ho, W.S., & Sirkar, K.K. (2001). Membrane Handbook. Van Nostrand Reinhold Publication.	
Reference Books		
1.	Perry, R.H., & Green, D. (1997). Perry Chemical Engineers Handbook (7th ed). McGraw-Hill.	
2.	Seader, J. D., & Henley, E. J. (2010). Separation Process Principles (3rd ed). John Wiley & Sons, Inc.	
3.	Randal F. Barron. (1999). Cryogenic Systems. Oxford University Press, New York.	
	Useful web links	
1.	https://nptel.ac.in/courses/103105061	
2.	https://archive.nptel.ac.in/content/storage2/courses/102103017	

Year, Program, Semester	Final Year B. Tech. (Chemical Engineering), Part IV, Semester VII							
Course Code	OEC411.1							
Course Category	Open Elective Course							
Course title	**Open Elective–II: Data Science (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)	ESC321, PCC322							
Course Rationale	Data Science integrates statistics, computer science, and domain knowledge to derive actionable insights from data. Engineers in every discipline now leverage data-driven methods for optimization, forecasting, process monitoring, and decision-making. This course provides foundational knowledge in data handling, analysis, visualization, and machine learning, preparing students to apply data science concepts in engineering, business, and research environments.							
Course Objectives	The course teacher will ensure to: 1. Describe data science fundamentals and workflows. 2. Demonstrate data collection and preprocessing methods. 3. Apply statistical techniques for data exploration. 4. Develop data visualization and interpretation skills. 5. Illustrate predictive modeling and machine learning. 6. Evaluate data science applications and ethics							
Course Outcomes	After completing the course, students will be able to: 1. Explain data science concepts and workflow. 2. Handle and preprocess structured data. 3. Apply statistical tools for data analysis. 4. Visualize and interpret data effectively. 5. Build simple predictive models. 6. Evaluate data-driven decisions and ethics.							

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	1	-	1	1	-	-	-	1	-	1
CO2	3	3	2	1	2	-	-	-	-	-	-	1
CO3	2	3	3	2	3	-	1	-	-	1	1	2
CO4	1	2	3	3	3	1	1	1	-	1	2	2
CO5	1	2	3	3	3	2	3	1	1	2	2	3
CO6	-	1	1	-	1	3	3	3	1	3	1	3

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

Unit No.	Course Content	Hours
I	Introduction to Data Science, Definition, scope, and importance of data science, Data-driven decision-making and applications in engineering, Role of statistics and computing in data analysis, Data science workflow: acquire, prepare, analyze, model, report	**05**
II	Data Acquisition and Preprocessing, Data types and formats (structured, unstructured, time-series), Data collection from sensors, databases, and web sources, Data cleaning, normalization, missing data handling, Tools: Excel, Python (pandas)	**06**
III	Exploratory Data Analysis, Descriptive statistics and data summarization, Measures of central tendency, variability, and correlation, Outlier detection and feature scaling, Case study: process data analytics	**07**
IV	Data Visualization and Interpretation: Principles of effective data visualization, Charts, plots, and dashboards (matplotlib, seaborn, Power BI), Communicating results through reports, Visual storytelling and decision insights	**07**
V	Introduction to Machine Learning: Supervised vs. unsupervised learning, Regression, classification, clustering (basic algorithms), Model training, testing, and evaluation metrics, Practical examples using open datasets	**07**
VI	Applications and Ethical Considerations: Industrial and social applications of data science, AI bias, privacy, and data protection, Responsible use of data and sustainability in analytics, Case studies in manufacturing, healthcare, and finance, Focus: Evaluation and creation (L5–L6; SOLO – Extended Abstract)	**07**
Text Books		
1.	Aggarwal, C.C. (2018). Machine Learning for Data Science. Springer, Cham.	
Reference Books		
1.	Provost, F., & Fawcett, T. (2013). Data Science for Business. O'Reilly Media, California.	
2.	James, G., Witten, D., Hastie, T., & Tibshirani, R. (2021). An Introduction to Statistical Learning with Applications in R. (2nd ed.). Springer, New York.	
3.	Nandakumar, K., & Kannan, R. (2020). Instrumentation and Process Control. PHI Learning, New Delhi.	

Year, Program, Semester	Final Year B. Tech. (Chemical Engineering), Part IV, Semester VII						
Course Code	OEC411.2						
Course Category	Open Elective Course						
Course title	**Open Elective–II: Supply Chain Management (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)	HSMEC321						
Course Rationale	Supply Chain Management (SCM) plays a pivotal role in ensuring the smooth flow of materials, information, and finances across production and service systems. For engineers, understanding SCM enhances their ability to optimize production efficiency, cost, and sustainability. This course introduces students to core principles, tools, and strategies of SCM — from procurement to distribution — while emphasizing technological integration, sustainability, and ethical management. It aims to develop analytical and managerial thinking relevant to modern industrial and business environments.						
Course Objectives	The course teacher will ensure to: 1. Explain fundamental supply chain system principles. 2. Detail planning and coordination management strategies. 3. Illustrate procurement, production, and distribution flows. 4. Apply inventory and logistics management tools. 5. Demonstrate digital and global SCM practices. 6. Discuss SCM sustainability and ethical issues.						
Course Outcomes	After completing the course, students will be able to: 1. Explain structure and functions of supply chains. 2. Analyse planning, sourcing, and logistics activities. 3. Apply inventory and distribution models. 4. Evaluate performance metrics in supply chains. 5. Discuss technology integration in global SCM. 6. Assess sustainability and ethics in SCM practice.						

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	1	-	1	1	-	-	-	1	-	1
CO2	2	3	2	1	2	1	-	-	-	-	-	1
CO3	1	3	3	2	3	-	-	-	-	1	1	2
CO4	1	2	3	3	3	2	1	1	-	1	2	2
CO5	1	2	3	3	3	2	3	1	1	2	2	3
CO6	-	1	1	-	1	3	3	3	1	3	1	3

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

Unit No.	Course Content	Hours
I	**Introduction to Supply Chain Management:** Definition, objectives, and scope of SCM, Components and processes in supply chains, Supply chain drivers: facilities, inventory, transportation, information, Role of SCM in manufacturing and service sectors	**04**
II	**Supply Chain Strategy and Planning:** Supply Chain Strategy and Planning: Strategic fit and alignment with business goals, Forecasting and demand planning, Supply chain network design and capacity planning, Aggregate planning and resource allocation	**07**
III	**Procurement and Inventory Management**: Sourcing strategies and supplier selection, Inventory classification and EOQ models, Safety stock and reorder point systems, Vendor-managed inventory (VMI) and JIT concepts	**07**
IV	**Logistics and Distribution Systems:** Transportation models and route optimization, Warehousing and material handling, Distribution network design, Performance measurement: SCOR model and KPIs	**07**
V	**Information Technology in Supply Chains:** Role of IT and data analytics in SCM, ERP, SAP, and digital SCM tools, IoT, AI, and blockchain in logistics, E-commerce and Industry 4.0 applications	**07**
VI	**Sustainable and Ethical Supply Chains:** Green logistics and circular economy approaches, Corporate social responsibility and fair-trade practices, Risk management and resilience in supply chains, Case studies on sustainable SCM practices	**07**
Reference Books		
1.	Chopra, S., & Meindl, P. (2022). Supply Chain Management: Strategy, Planning, and Operation (8th ed.). Pearson Education, New Jersey.	
2.	Sunil Sharma (2018). Operations and Supply Chain Management. Oxford University Press, New Delhi.	
3.	Ballou, R.H. (2007). The Theory and Practice of Logistics and Supply Chain Management. Pearson Education, Singapore.	
4.	Stadtler, H., Kilger, C., & Meyr, H. (2015). Supply Chain Management and Advanced Planning: Concepts, Models, Software, and Case Studies. Springer, Berlin.	
5.	Sahay, B.S., & Mohan, R. (2006). Supply Chain Management for Global Competitiveness. Macmillan India, New Delhi.	

Year, Program, Semester	Final Year B. Tech. (Chemical Engineering), Part IV, Semester VII						
Course Code	OEC411.3						
Course Category	Open Elective Course						
Course title	**Open Elective–II: Total Quality Management (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)	HSMEC321						
Course Rationale	Quality is a key differentiator in engineering and manufacturing. Total Quality Management (TQM) integrates engineering principles, statistical methods, and managerial strategies to ensure excellence in products, services, and processes. This course provides students with a structured understanding of TQM concepts, tools, and techniques, enabling them to analyze, improve, and sustain quality systems in engineering and service organizations. It enhances students' ability to think systematically, focus on continuous improvement, and apply ISO, Six Sigma, and Kaizen principles in professional practice.						
Course Objectives	The course teacher will ensure to: 1. Explain quality management concepts and principles. 2. Detail quality planning and improvement approaches. 3. Illustrate tools and techniques for quality. 4. Apply statistical and managerial improvement methods. 5. Demonstrate ISO standards and Six Sigma. 6. Promote continuous improvement and customer focus.						
Course Outcomes	After completing the course, students will be able to: 1. Explain the philosophy and elements of TQM. 2. Apply quality control and improvement tools. 3. Analyse process variation using statistical methods. 4. Evaluate ISO and Six Sigma quality systems. 5. Design continuous improvement initiatives. 6. Demonstrate teamwork and communication in quality projects.						

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	1	-	-	1	-	-	-	1	-	1
CO2	2	3	2	1	2	1	-	-	-	-	-	1
CO3	1	3	3	2	3	-	-	-	-	1	1	2
CO4	1	2	3	3	3	2	1	1	-	1	2	2
CO5	1	2	3	3	3	2	3	1	1	2	2	3
CO6	-	1	1	-	1	3	3	3	1	3	1	3

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

Unit No.	Course Content	Hours
I	**Introduction to Quality and TQM:** Definition, dimensions, and evolution of quality, Principles of TQM and Deming's philosophy, Role of top management and organizational culture, Quality planning and customer satisfaction	**04**
II	**Quality Management Tools and Techniques:** Seven basic tools of quality: Pareto chart, cause–effect diagram, control charts, etc., New management tools for planning and analysis, Benchmarking and Quality Function Deployment (QFD), Failure Mode and Effect Analysis (FMEA)	**07**
III	**Statistical Quality Control:** Control charts for variables and attributes, Process capability analysis, Sampling plans and acceptance criteria, Statistical software tools for process analysis	**07**
IV	**ISO Standards and Quality Systems**: ISO 9000 family of standards and certification, Documentation, auditing, and implementation procedures, Total Productive Maintenance (TPM) and Quality Circles, Case study on ISO implementation in industries	**07**
V	**Six Sigma and Lean Principles**: Six Sigma methodology and DMAIC process, Lean manufacturing and waste reduction, Integration of Lean and Six Sigma, Case studies on process excellence and cost reduction	**07**
VI	**Continuous Improvement and Future Trends:** Kaizen, 5S, and Poka-Yoke concepts, Quality leadership and culture building, Business Excellence Models (EFQM, Malcolm Baldrige), Emerging quality challenges in digital manufacturing	**07**
Reference Books		
1.	Besterfield, D. H. (2014). Total Quality Management (4th ed.). Pearson Education, New Delhi.	
2.	Oakland, J.S. (2018). Total Quality Management and Operational Excellence (5th ed.). Routledge, London.	
3.	Evans, J.R., & Lindsay, W.M. (2017). Managing for Quality and Performance Excellence. (10th ed.). Cengage Learning, Boston.	
4.	Mitra, A. (2016). Fundamentals of Quality Control and Improvement (4th ed.). Wiley, New Jersey.	
5.	Kiran, D.R. (2017). Total Quality Management: Key Concepts and Case Studies. Butterworth-Heinemann (Elsevier), Oxford.	

Year, Program, Semester	Final Year B. Tech. (Chemical Engineering), Part IV, Semester VII							
Course Code	OEC411.4							
Course Category	Open Elective Course							
Course title	**Open Elective II – Fundamentals of Digital Marketing and E-Commerce (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)	HSMEC111, HSMEC121							
Course Rationale	Digital marketing and e-commerce have transformed the global business landscape by merging technology, analytics, and customer-centric design. Engineers equipped with these competencies can contribute to digital product design, data-driven decision-making, and innovative online business models. This course introduces the concepts, tools, and technologies of digital marketing and e-commerce, emphasizing strategy formulation, web analytics, social-media integration, and ethical digital practices.							
Course Objectives	The course teacher will ensure to: 1. Describe digital marketing and e-commerce concepts. 2. Detail online consumer behavior and analysis. 3. Demonstrate digital marketing tools and platforms. 4. Apply SEO, SEM, and analytics techniques. 5. Examine e-commerce models and technical frameworks. 6. Evaluate online ethics, security, and sustainability.							
Course Outcomes	After completing the course, students will be able to: 1. Explain basics of digital marketing and e-commerce. 2. Identify digital channels and customer segments. 3. Apply SEO/SEM and content-marketing tools. 4. Analyse e-commerce models and payment systems. 5. Evaluate digital strategies using analytics. 6. Discuss ethics, privacy, and sustainability issues.							

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	1	-	-	1	1	-	-	-	1	-	1
CO2	2	2	1	1	2	-	-	-	-	-	-	1
CO3	1	3	2	2	3	-	-	-	-	1	1	2
CO4	1	2	3	3	3	1	1	1	-	1	2	2
CO5	1	2	3	3	3	2	3	1	1	2	2	3
CO6	-	1	1	-	1	3	3	3	1	3	1	3

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

Unit No.	Course Content	Hours
I	**Introduction to Digital Marketing and E-Commerce:** Evolution and scope of digital marketing, Digital vs. traditional marketing, Overview of e-commerce concepts and business models, Components of digital marketing ecosystem	**05**
II	**Digital Consumer Behaviour and Market Research**: Online consumer decision-making process, Market segmentation and targeting in digital space, Competitor and keyword analysis, Tools for digital research and data collection	**07**
III	**Digital Marketing Tools and Techniques:** Search Engine Optimization (SEO) and Search Engine Marketing (SEM), Social-media marketing, influencer campaigns, and content strategy, Email and mobile marketing, Pay-per-click (PPC) advertising	**07**
IV	**E-Commerce Technologies and Operation**: E-commerce infrastructure and web technologies, Payment gateways and security mechanisms, Logistics, fulfilment, and inventory in e-commerce, Cloud and mobile commerce applications	**07**
V	**Analytics and Performance Measurement**: Web analytics and data interpretation (Google Analytics), Key performance indicators (KPIs), Conversion-rate optimization and A/B testing, Data-driven marketing decisions	**07**
VI	**Ethics, Security and Future Trends**: Ethical and legal issues in digital marketing, Privacy, cyber security, and consumer protection, Green digital marketing and sustainability, Future trends: AI marketing, AR/VR commerce	**06**
Reference Books		
1.	Chaffey, D., & Ellis-Chadwick, F. (2020). Digital Marketing (8th ed.). Pearson Education, London.	
2.	Kotler, P., Kartajaya, H., & Setiawan, I. (2017). Marketing 4.0: Moving from Traditional to Digital. Wiley, New Jersey.	
3.	Ryan, D. (2016). Understanding Digital Marketing (4th ed.). Kogan Page, London.	
4.	Turban, E., King, D., Lee, J.K., & Liang, T.P. (2022). Electronic Commerce: A Managerial and Social Networks Perspective (10th ed.). Springer, Singapore.	
5.	Tiago, M.T.P.M.B., & Verissimo, J.M.C. (2014). Digital Marketing and Social Media: An Integrated Approach. Elsevier Journals, Amsterdam.	

Year, Program, Semester	Final Year B. Tech. (Chemical Engineering), Part IV, Semester VII						
Course Code	PSI411						
Course Category	Project Seminar Internship						
Course title	**Major Project Phase-I (Laboratory)**						
Teaching Scheme and Credits	**L**	**T**	**P**	**Total Contact Hours**		**Total Credits**	
	-	01	02	03		02	
Evaluation Scheme	**ISE**	**ESE**		**IOE**	**IPE**	**EOE**	**EPE**	**Total**
	-	-		50	-	100	-	150
Pre-requisites (if any)	PCC212, PCC221, PCC224, PCC311, PPCC312, PCC321						
Course Rationale	The Major Project Work course provides students with a professional, research-oriented capstone experience, focusing on problem conceptualization, literature-driven investigation, project planning, progress monitoring, and technical communication. Unlike laboratory-intensive work, this course emphasizes seminar presentations, internships, industry/research exposure, documentation, and critical evaluation. Aligned with international capstone and senior thesis models, the course develops independent learning, research aptitude, project management, ethical awareness, and professional communication, preparing graduates for industry roles, higher studies, entrepreneurship, and R&D careers.						
Course Objectives	The course teacher will ensure to: 1. Guide identification of complex engineering problems. 2. Define project objectives, scope, and methodology. 3. Mentor project planning, resources, and risks. 4. Evaluate technical progress through periodic reviews. 5. Incorporate ethics, safety, and sustainability principles. 6. Train technical reporting and presentation skills.						
Course Outcomes	After completing the course, students will be able to: 1. Develop technically sound, literature-supported project proposals. 2. Design feasible project execution and resource plans. 3. Monitor project progress using structured milestones. 4. Evaluate engineering feasibility, sustainability, and ethics. 5. Demonstrate professional conduct and effective teamwork. 6. Produce high-quality technical reports and presentations.						

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	3	1	2	-	-	-	1	-	1	-	1
CO2	2	2	3	1	1	-	-	1	-	-	3	-
CO3	1	1	2	-	-	-	-	1	1	-	3	-
CO4	1	2	1	3	-	2	3	3	-	-	-	-
CO5	-	1	-	-	-	1	1	3	3	2	1	-
CO6	-	-	-	-	-	-	-	1	2	3	-	1

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

Course Content

The students are required to carry out projects related to the field of Chemical Engineering with emphasis on:

- Identification of a **realistic chemical engineering problem** through literature survey, industry interaction, or internship exposure
- Formulation of **project objectives, scope, and methodology** based on engineering principles
- Planning and monitoring of project activities through **periodic reviews and seminars**
- Application of chemical engineering knowledge considering **safety, sustainability, ethics, and societal impact**
- Development of **professional skills**, including teamwork, independent responsibility, and time management
- Preparation and presentation of **technical reports, seminars, and viva-voce**

Course Assessment Process

The assessment of the Major Project Work shall be carried out through **continuous internal evaluation** and **external evaluation** as per university norms.

- **Internal Evaluation (IE):** The internal assessment shall be conducted by the **course teacher / project supervisor**, based on:
  - Project proposal and literature review
  - Periodic progress reviews and seminars
  - Quality of project planning and documentation
  - Student involvement, initiative, and adherence to timelines
- **External Evaluation (EE):** The external assessment shall be conducted by a **panel of external examiners** appointed by the university, based on:
  - Final project report
  - Oral presentation and viva voce
  - Technical depth, originality, and problem-solving approach
  - Consideration of safety, sustainability, and ethical aspects.

Reference Books

1.	Kothari, C. R., & Garg, G. (2019). Research Methodology: Methods and Techniques (4th ed.). New Delhi.

2.	Wysocki, R. K. (2013). Effective Project Management: Traditional, Agile, Extreme (7th ed.). Indianapolis, IN: Wiley.
3.	Beer, D. F., & McMurrey, D. A. (2014). A Guide to Writing as an Engineer (4th ed.). Hoboken, NJ: Wiley.
4.	Perry, R. H., Green, D. W., & Southard, M. Z. (2019). Perry's chemical engineers' handbook (9th ed.). McGraw-Hill Education, New York.
	Useful web links
1.	https://usic.sheffield.ac.uk/blog/how-to-do-a-research-project
2.	https://www.coursera.org/learn/research-methods

Year, Program, Semester	Final Year B. Tech. (Chemical Engineering), Part IV, Semester VII							
Course Code	VEC411							
Course Category	Value Education Course							
Course title	**Green Technology & Sustainability**							
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)	HSMEC211, HSMEC221, PCC212, ESC211							
Course Rationale	This course introduces students of all engineering disciplines to the concepts and practices of sustainable development, emphasizing environmentally responsible engineering design and operation. It aims to develop awareness, critical understanding, and innovation for applying green technologies that minimize resource consumption, reduce pollution, and promote circular economy approaches. The course empowers engineers to integrate sustainability principles in diverse fields such as manufacturing, infrastructure, computing, food systems, and communication technologies.							
Course Objectives	The course teacher will ensure to: 1. Explain core principles of global sustainability. 2. Detail green technology and eco-innovation concepts. 3. Assess environmental impacts of engineering systems. 4. Identify renewable and resource-efficient alternatives. 5. Integrate sustainable practices in process design. 6. Promote responsible and ethical engineering decisions.							
Course Outcomes	After completing the course, students will be able to: 1. Explain sustainability and green engineering principles. 2. Identify major environmental and resource issues. 3. Apply life-cycle and impact assessment tools. 4. Evaluate cleaner and renewable technologies. 5. Design eco-efficient and sustainable solutions. 6. Communicate sustainability ideas effectively.							

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	1	-	-	-	2	3	2	-	1	-	1
CO2	2	2	-	1	-	2	3	-	-	-	-	1
CO3	1	3	2	2	2	-	3	-	-	-	-	2
CO4	1	2	3	2	2	1	3	1	-	1	-	2
CO5	1	2	3	2	2	2	3	2	1	2	2	3
CO6	-	-	1	-	1	-	2	2	2	3	1	2

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

Unit No.	Course Content	Hours
I	**Sustainability Fundamentals:** Definition and dimensions of sustainability (environmental, social, economic), Sustainable Development Goals (SDGs) and their engineering relevance, Principles of green engineering and sustainable innovation	**02**
II	**Environmental Challenges & Resource Management:** Global and local environmental issues, Energy, water, and material resource depletion, Waste generation and its impact across industries	**02**
III	**Green Technologies & Eco-Innovation**: Concepts and case studies in clean and green technologies, Sustainable materials, cleaner manufacturing, digital sustainability (IoT, AI for energy management), Smart cities, green buildings, and sustainable mobility	**02**
IV	**Life Cycle Thinking & Environmental Assessment:** Basics of Life Cycle Assessment (LCA), Carbon and water foot printing, Environmental performance indicators and sustainability metrics	**03**
V	**Renewable Energy and Sustainable Systems:** Solar, wind, hydro, bioenergy, and hydrogen systems, Energy conservation and efficiency improvement, Integration of renewable technologies into engineering design	**02**
VI	**Circular Economy & Sustainable Future**: Waste-to-wealth concepts, Product stewardship, recycling loops, Ethical, economic, and policy aspects of sustainability, Case studies and communication of sustainability projects	**02**
Reference Books		
1.	Allen, D.T., & Shonnard, D.R. (2001). Green Engineering: Environmentally Conscious Design of Chemical Processes. Prentice Hall, New Jersey.	
2.	Anastas, P.T., & Zimmerman, J.B. (2018). The Twelve Principles of Green Chemistry and Engineering. Oxford University Press, Oxford.	
3.	Graedel, T.E., & Allenby, B.R. (2010). Industrial Ecology and Sustainable Engineering. Pearson Education, New Jersey.	
4.	Rao, S.S., & Parulekar, A.H. (2022). Sustainable Engineering: Concepts, Design, and Case Studies. McGraw-Hill Education, New Delhi.	
5.	Azapagic, A., Perdan, S., & Clift, R. (2004). Sustainable Development in Practice: Case Studies for Engineers and Scientists. John Wiley & Sons, Chichester.	

Year, Program, Semester	Final Year B. Tech. (Chemical Engineering), Part IV, Semester VII						
Course Code	PSI412						
Course Category	Project Seminar Internship						
Course title	**MDM based Industry Internship ***						
Teaching Scheme and Credits	**L**	**T**	**P**	**Total Contact Hours**	**Total Credits**		
	-	-	-	One month duration	03		
Evaluation Scheme	**ISE**	**ESE**		**IOE**	**IPE**	**EOE**	**EPE**	**Total**
	-	-		50	-	50	-	100
Pre-requisites (if any)	PCC212, PCC221, PCC222, PCC224, AEC211						

***Note: MDM based Industry Internship:** There is a pool of MDM programs with three different options namely Food Process Engineering, Artificial Intelligence and Machine Learning and Piping Design Engineering

The students have to undergo an internship in an industry relevant to the chosen MDM program.

Year, Program, Semester	Final Year B. Tech. (Chemical Engineering), Part IV, Semester VII				
Course Code	PBL411				
Course Category	Project Based Learning				
Course title	**Major Project Lab**				
Teaching Scheme and Credits	**L**	**T**	**P**	**Total Contact Hours**	**Total Credits**
	--	01	02	03	--
Evaluation Scheme	IE at Course in charge end				
Pre-requisites (if any)	PCC212, PCC221, PCC222, PCC224, PCC311, PCC312, PCC321				
Course Rationale	The Major Project Laboratory course emphasizes hands-on, solution-driven project execution, where students design, build, test, analyze, and optimize chemical engineering systems or processes. This course translates theory into practice through experimental work, pilot-scale studies, simulations, and prototype development. Anchored in global Project-Based Learning (PBL) models, the course develops higher-order problem-solving skills, experimental competence, data analysis ability, and innovation mindset, ensuring graduates are industry-ready and practice-oriented.				
Course Objectives	The course teacher will ensure to: 1. Translate engineering problems into experimental tasks. 2. Guide design of laboratory-scale prototype systems. 3. Enforce safe operation and standard procedures. 4. Demonstrate data analysis using statistical techniques. 5. Discuss process optimization and performance constraints. 6. Train technical documentation and project demonstrations.				
Course Outcomes	After completing the course, students will be able to: 1. Implement working laboratory or simulation models. 2. Conduct experiments adhering to safety standards. 3. Analyse data to identify performance trends. 4. Optimize project outcomes using engineering evidence. 5. Demonstrate hands-on competence and teamwork. 6. Produce comprehensive laboratory reports and demonstrations.				

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	3	1	2	-	-	1	1	-	1	-
CO2	2	2	2	-	1	1	1	2	1	-	1	-
CO3	1	3	1	2	1	-	-	1	-	-	-	-
CO4	1	2	2	3	1	1	2	2	-	-	1	-
CO5	-	1	-	-	-	1	1	3	3	1	1	-
CO6	-	-	-	-	1	-	-	1	2	3	-	1

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

Course Content
The students are required to carry out hands-on project-based laboratory work related to the field of Chemical Engineering with emphasis on: • Translation of the selected project problem into experimental, computational, or process-based tasks • Design, setup, and execution of laboratory experiments, simulations, or prototype systems • Safe operation of equipment and adherence to standard operating procedures and laboratory safety practices • Collection, analysis, and interpretation of experimental or simulated data • Optimization and validation of project outcomes considering performance, safety, sustainability, and cost • Documentation and demonstration of results through laboratory reports and final project presentations.
Course Assessment Process
The assessment of the Major Project Laboratory shall be carried out through **continuous internal evaluation** by the **course in-charge / project supervisor**, focusing on hands-on performance and project execution. Evaluation shall be entirely based on continuous assessment by the course in-charge. The internal assessment shall be based on: • Laboratory work and experimental execution • Proper use of equipment and adherence to safety practices • Data collection, analysis, and interpretation • Teamwork, regularity, and responsibility in laboratory work • Laboratory records, interim reports, and final project demonstration

Reference Books	
1.	Kothari, C. R., & Garg, G. (2019). Research methodology: Methods and techniques (4th ed.). New Age International, New Delhi.
2.	Kerzner, H. (2017). Project management: A systems approach to planning, scheduling, and controlling (12th ed.). Wiley, Hoboken, NJ.
3.	Booth, W. C., Colomb, G. G., Williams, J. M., Bizup, J., & Fitzgerald, W. T. (2016). The craft of research (4th ed.). University of Chicago Press, Chicago.
4.	Beer, D. F., & McMurrey, D. A. (2014). A guide to writing as an engineer (4th ed.). Wiley, Hoboken, NJ.
5.	Perry, R. H., Green, D. W., & Southard, M. Z. (2019). Perry's chemical engineers' handbook (9th ed.). McGraw-Hill Education, New York.
	Useful web links
1.	https://www.vlab.co.in/
2.	https://www.iprojectmaster.com/final-year-projects-materials/chemical-engineering

Year, Program, Semester	Final Year B. Tech. (Chemical Engineering), Part IV, Semester VIII						
Course Code	PSI421						
Course Category	Project Seminar Internship						
Course title	**Industrial Internship & Major Project Phase-II**						
Teaching Scheme and Credits	**L**	**T**	**P**	**Total Contact Hours**	**Total Credits**		
	Entire Semester is to be spent in the industry				10		
Evaluation Scheme	**ISE**	**ESE**		**IOE**	**IPE**	**EOE**	**EPE**	**Total**
	-	-		150	-	200	-	350
Pre-requisites (if any)	Basic chemical engineering courses						
Course Rationale	This course provides full-semester industrial exposure to students, enabling them to gain real-time experience in professional work environments. It bridges theoretical knowledge with practical application, builds industry-relevant skills, and prepares students for employment through hands-on learning, teamwork, and professional ethics.						
Course Objectives	The course teacher will ensure to: 1. Provide semester-long industrial and project exposure. 2. Develop technical skills through real-world tasks. 3. Facilitate solving industry-linked engineering challenges. 4. Foster professional behavior and ethical conduct. 5. Enhance teamwork and professional communication skills. 6. Ensure career readiness and lifelong learning.						
Course Outcomes	After completing the course, students will be able to: 1. Explain industrial structures, workflows, and standards. 2. Analyze real-world industrial and project problems. 3. Apply academic knowledge to industrial projects. 4. Utilize modern industrial tools and technologies. 5. Communicate work through professional technical reports. 6. Demonstrate professionalism and independent lifelong learning.						

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	1	-	-	-	2	1	1	1	1	-	2
CO2	3	3	2	2	1	1	1	1	1	1	-	2
CO3	3	2	3	2	2	1	1	1	1	1	-	2
CO4	3	3	2	3	3	1	1	1	1	1	-	2
CO5	2	1	1	1	1	2	2	2	1	1	-	1
CO6	1	1	1	1	1	2	2	2	1	1	1	3

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

Course Content
The **Industrial Internship & Major Project Phase-II** is a full-semester integrated program conducted in reputed industries, R&D organizations, startups, or government sectors relevant to Chemical Engineering. This course combines intensive industrial training with the execution of the **final-year capstone project**. Students work under the dual guidance of industry and faculty mentors to solve **complex engineering problems** or execute **industrial projects** involving pharmaceuticals, petrochemicals, water treatment, or specialized manufacturing. The course emphasizes the practical implementation of Chemical Engineering principles, process optimization, professional ethics, and technical documentation. Students must maintain a daily logbook, submit periodic progress reports, and deliver a comprehensive final report that integrates both internship learning and project outcomes. **Guidelines, Rules, and Regulations** • **Duration and Scope:** All B.Tech Chemical Engineering students must complete this integrated course during the eighth semester. It encompasses both extensive industrial exposure and the finalization of the Major Project. • **Placement:** The program must be carried out for one full semester in an approved organization recommended by the department. An official offer or confirmation letter must be submitted before commencement. • **Mentorship:** Each student is assigned a **Faculty Mentor** and an **Industry Supervisor**. Both will jointly monitor technical progress, project milestones, and professional development. • **Compliance:** Students must strictly adhere to the organization's safety policies, confidentiality agreements, and ethical standards. Misconduct or unauthorized change of organization will lead to disciplinary action. • **Documentation:** Students must submit a **Detailed Integrated Report** (prescribed format) along with an Internship Completion Certificate and a Project Completion Statement signed by the industry supervisor. • **Credit Award:** Failure to complete the internship hours or meet the project deliverables within the stipulated time will result in the non-award of credits.
Course Assessment Process
Assessment is conducted through a **Joint Evaluation Process** involving the Industry Supervisor and a Departmental Committee. The evaluation is based on: 1. **Technical Competence:** Application of engineering knowledge to industry/project tasks. 2. **Project Deliverables:** Quality and validation of the Major Project outcomes. 3. **Documentation:** Accuracy of the daily logbook and the final integrated report. 4. **Presentation & Viva:** A final seminar demonstrating problem-solving and professional communication. 5. **Professionalism:** Feedback from the industry mentor regarding attitude and teamwork. Internal Evaluation (IE) and End Examination (EE) marks shall be awarded according to the institute's academic regulations.

Year, Program, Semester	Final Year B. Tech. (Chemical Engineering), Part IV, Semester VIII							
Course Code	PEC421.1							
Course Category	Program Elective Course (Online)							
Course title	**Program Elective-III: Computational Fluid Mechanics(Online) (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)	BSC212, PCC211, PCC221							
Course Rationale	Fluid mechanics governs the behaviour of most chemical processes — from reactors and heat exchangers to pipelines and distillation columns. However, many real-world systems are too complex for analytical solutions. This course develops the ability to apply numerical methods and computational tools to simulate and analyze fluid flow, heat, and mass transfer systems. Students learn to model, discretize, and interpret flow phenomena using computational approaches and commercial software.							
Course Objectives	The course teacher will ensure to: 1. Explain fundamental computational fluid mechanics principles. 2. Derive governing equations for fluid flow. 3. Demonstrate discretization techniques and numerical methods. 4. Solve flow problems using finite volumes. 5. Interpret simulation results for engineering applications. 6. Train students in industrial CFD software.							
Course Outcomes	After completing the course, students will be able to: 1. Explain governing equations of fluid flow and transport. 2. Apply discretization methods to flow equations. 3. Implement numerical schemes for simple flow problems. 4. Analyse flow and heat transfer using CFD concepts. 5. Evaluate simulation results for engineering systems. 6. Discuss CFD applications in process industries.							

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	1	-	1	1	-	-	-	1	-	1
CO2	3	3	2	1	2	-	-	-	-	-	-	1
CO3	2	3	3	2	3	-	1	-	-	1	1	2
CO4	1	2	3	3	3	1	1	1	-	1	2	2
CO5	1	2	3	3	3	2	3	1	1	2	2	3
CO6	-	1	1	-	1	3	3	3	1	3	1	3

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

Unit No.	Course Content	Hours
I	**Introduction to Computational Fluid Mechanics:** Overview of CFD and its applications in chemical engineering, Mathematical formulation of fluid flow problems, Continuum assumption and control volume approach, Steps in CFD simulation and modelling workflow.	**4**
II	**Governing Equations of Fluid Flow:** Continuity, momentum (Navier–Stokes), and energy equations, Boundary and initial conditions, Simplifications for laminar, turbulent, and compressible flow, Integral and differential forms	**6**
III	**Discretization and Numerical Methods**: Finite difference and finite volume methods, Discretization of partial differential equations, Explicit and implicit schemes, stability, and convergence, Grid generation and boundary treatment	**7**
IV	**Solution of Flow Problems:** Pressure–velocity coupling: SIMPLE, SIMPLER, and PISO algorithms, Solution of algebraic equations (Gauss-Seidel, TDMA), Treatment of convection and diffusion terms, Case study: 2D steady laminar flow in a duct.	**8**
V	**Turbulence modelling and Heat Transfer:** Introduction to turbulence and Reynolds-averaged equations, Turbulence models: k–ε, k–ω, and LES concepts, Energy equation discretization and coupling with flow field, CFD analysis of heat exchangers and reactors	**7**
VI	**CFD Software and Industrial Applications:** Overview of commercial CFD packages (ANSYS Fluent, OpenFOAM, COMSOL), Steps in pre-processing, solving, and post-processing, Validation and verification of CFD results, Case studies: flow over a valve, mixing tank, and cyclone separator	**7**
Reference Books		
1.	Versteeg, H.K., & Malalasekera, W. (2007). An Introduction to Computational Fluid Dynamics: The Finite Volume Method (2nd ed.). Pearson Education, London.	
2.	Anderson, J.D. (2015). Computational Fluid Dynamics: The Basics with Applications. McGraw-Hill, New York.	
3.	Patankar, S.V. (1980). Numerical Heat Transfer and Fluid Flow. Hemisphere Publishing, Washington DC.	
4.	Ferziger, J.H., Peric, M., & Street, R.L. (2020). Computational Methods for Fluid Dynamics. Springer, Cham.	
5.	Moukalled, F., Mangani, L., & Darwish, M. (2016). The Finite Volume Method in Computational Fluid Dynamics: An Advanced Introduction. Springer, Berlin.	

Year, Program, Semester	Final Year B. Tech. (Chemical Engineering), Part IV, Semester VIII						
Course Code	PEC421.2						
Course Category	Program Elective Course (Online)						
Course title	**Program Elective-III: Introduction to Nanotechnology (Online) (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)	ESC211, BSC211, BSC211, BSC111, BSC112						
Course Rationale	Nanotechnology is an enabling field that bridges materials science, chemistry, and engineering to manipulate matter at the nanoscale (1–100 nm). Understanding nanoscale phenomena and materials behaviour is crucial for innovations in energy, environment, healthcare, catalysis, and advanced manufacturing. This course introduces the fundamentals of nanoscience, synthesis, and characterization of nanomaterials, along with their diverse applications in engineering systems. It provides Chemical Engineering students with conceptual grounding and technological exposure to design, handle, and evaluate Nano-systems in a sustainable and responsible manner.						
Course Objectives	The course teacher will ensure to: 1. Explain fundamental concepts and nanotechnology scope. 2. Describe material properties at the nanoscale. 3. Detail nanomaterial synthesis and fabrication methods. 4. Demonstrate techniques for nanomaterial characterization. 5. Illustrate engineering applications of specialized nanomaterials. 6. Discuss safety, ethics, and sustainability principles.						
Course Outcomes	After completing the course, students will be able to: 1. Explain fundamental concepts of nanoscience. 2. Identify unique properties of nanomaterials. 3. Describe synthesis and fabrication techniques. 4. Apply characterization tools for nanomaterials. 5. Evaluate engineering applications of nanotechnology. 6. Describe safety, ethics, and sustainability principles.						

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	-	-	1	-	1
CO2	3	3	1	1	2	-	2	-	-	-	-	1
CO3	2	3	2	2	3	-	2	-	-	-	-	2
CO4	2	2	3	3	3	1	2	-	-	1	-	2
CO5	1	2	3	2	3	2	3	1	1	2	2	3
CO6	-	1	1	-	1	3	3	3	1	3	1	3

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

Unit No.	Course Content	Hours
I	**Introduction to Nanoscience and Nanotechnology:** Definition, history, and evolution of nanotechnology, Quantum size effects and surface-to-volume ratio significance, Classification: nanoparticles, nanowires, nanotubes, thin films, Interdisciplinary relevance: physics, chemistry, biology, engineering	**05**
II	**Properties of Nanomaterials:** Electrical, optical, magnetic, mechanical, and thermal properties at nanoscale, Influence of particle size, shape, and structure on properties, Surface energy, defects, and confinement effects, Role of nanostructures in chemical reactivity and catalysis	**07**
III	**Synthesis and Fabrication of Nanomaterials:** Top-down and bottom-up approaches, Chemical vapor deposition, sol-gel method, hydrothermal synthesis, Mechanical milling, lithography, and self-assembly, Biological and green synthesis routes	**07**
IV	**Characterization Techniques:** X-ray diffraction (XRD), SEM, TEM, AFM, and STM, Particle size analysis and zeta potential, Spectroscopic methods: UV-Vis, FTIR, Raman, Surface area and porosity analysis (BET method)	**06**
V	**Applications of Nanotechnology:** Nanomaterials in catalysis, sensors, coatings, drug delivery, water treatment, Nanoelectronics, energy storage, and conversion (solar cells, batteries), Nanocomposites and membranes, Case studies in chemical and environmental engineering	**07**
VI	**Environmental, Safety, and Ethical Issues**: Toxicology and environmental impact of nanomaterials, Risk assessment and safe handling of nanomaterials, Regulatory frameworks and sustainability concerns, Ethical aspects of nanotechnology in society	**07**
Reference Books		
1.	Poole, C.P., & Owens, F.J. (2003). Introduction to Nanotechnology. John Wiley & Sons, New Jersey.	
2.	Kulkarni, S.K. (2015). Nanotechnology: Principles and Practices. Springer, New Delhi.	
3.	Hornyak, G.L., Tibbals, H.F., Dutta, J., & Moore, J.J. (2008). Introduction to Nanoscience and Nanotechnology. CRC Press, Boca Raton.	
4.	Ratner, M., & Ratner, D. (2003). Nanotechnology: A Gentle Introduction to the Next Big Idea. Pearson Education.	
5.	Bandyopadhyay, A.K. (2010). Nano Materials. New Age International Publishers, New Delhi.	

Year, Program, Semester	Final Year B. Tech. (Chemical Engineering), Part IV, Semester VIII							
Course Code	PEC421.3							
Course Category	Program Elective Course (Online)							
Course title	**Program Elective-III: AI & ML Applications for Chemical Engineers (Online) (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)	ESC113, BSC212, PCC224, ESC321							
Course Rationale	The emergence of AI and Machine Learning is transforming chemical industries through process optimization, predictive maintenance, energy efficiency, and smart automation. This course introduces students to AI and ML principles, emphasizing their applications in chemical process modelling, control, design, and fault diagnosis. Students will gain the ability to handle real process data and apply algorithms for decision-making and innovation in chemical engineering.							
Course Objectives	The course teacher will ensure to: 1. Explain AI and ML fundamentals for engineers. 2. Detail data handling and feature extraction methods. 3. Apply machine learning algorithms to chemical processes. 4. Demonstrate AI-based modeling, simulation, and optimization. 5. Evaluate intelligent systems for control and safety. 6. Showcase emerging industrial AI applications and tools.							
Course Outcomes	After completing the course, students will be able to: 1. Explain AI and ML concepts relevant to process systems. 2. Prepare and preprocess engineering datasets. 3. Apply ML algorithms for prediction and classification. 4. Develop AI-based models for process optimization. 5. Evaluate intelligent control and monitoring systems. 6. Analyse industrial case studies in AI-driven chemical plants.							

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	1	-	1	1	-	-	-	1	-	1
CO2	3	3	2	1	2	-	-	-	-	-	-	1
CO3	2	3	3	2	3	-	1	-	-	1	1	2
CO4	1	2	3	3	3	1	1	1	-	1	2	2
CO5	1	2	3	3	3	2	3	1	1	2	2	3
CO6	-	1	1	-	1	3	3	3	1	3	1	3

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

Unit No.	Course Content	Hours
I	Introduction to AI and ML in Chemical Engineering: AI vs. ML vs. Deep Learning, Role of AI in process industries, Overview of data-driven and first-principle modelling, Case examples: smart manufacturing and Industry 4.0	**05**
II	Data Handling and Preprocessing: Process data types and sources (sensors, historians, lab data), Data cleaning, scaling, and normalization, Feature selection and extraction, Dimensionality reduction (PCA) and data visualization	**06**
III	Machine Learning Algorithms: Supervised learning: linear regression, decision trees, random forests, Unsupervised learning: clustering and principal component methods, Model training, validation, and cross-validation, Evaluation metrics (MAE, RMSE, confusion matrix)	**07**
IV	AI in Process Modeling and Simulation: Hybrid modeling: combining mechanistic and data-driven models, ANN (Artificial Neural Networks) and deep learning basics, Process simulation and soft sensor development, Case study: reactor and distillation modeling using ML	**07**
V	AI in Process Control and Optimization: Adaptive and predictive control systems, Reinforcement learning for process optimization, Fault detection and diagnosis using AI, Digital twins and smart plant monitoring	**07**
VI	Industrial Applications and Emerging Trends, AI applications in chemical, petrochemical, and energy sectors, Process safety and anomaly detection, Ethics, interpretability, and sustainability in AI systems, Future directions: autonomous chemical plants	**07**
Text Books		
1.	Bequette, B.W. (2020). Process Control: Modelling, Design and Simulation. Prentice Hall, New Jersey.	
Reference Books		
1.	Venkatasubramanian, V. (2019). Artificial Intelligence in Process Systems Engineering. Elsevier, Amsterdam.	
2.	Montgomery, D.C., & Runger, G.C. (2018). Applied Statistics and Probability for Engineers (7th ed.). Wiley, New York.	
3.	Bishop, C.M. (2006). Pattern Recognition and Machine Learning. Springer, New York.	
4.	Russell, S.J., & Norvig, P. (2021). Artificial Intelligence: A Modern Approach (4th ed.). Pearson Education, London.	

Year, Program, Semester	Final Year B. Tech. (Chemical Engineering), Part IV, Semester VIII							
Course Code	PEC421.4							
Course Category	Program Elective Course (Online)							
Course title	**Program Elective-III: Process Economics & Project Engineering(Online) (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)	PCC322							
Course Rationale	Chemical process design must be economically viable and well-managed from concept to commissioning. This course blends engineering economics, project evaluation, and management tools, helping students develop decision-making skills in cost estimation, profitability analysis, and project execution. It bridges technical and managerial perspectives, enabling engineers to evaluate the economic sustainability and feasibility of process industries							
Course Objectives	The course teacher will ensure to: 1. Explain economic principles of process design. 2. Detail cost estimation and profitability evaluation. 3. Apply project scheduling and budgeting techniques. 4. Analyse capital investment and risk assessment. 5. Discuss equipment design economics and depreciation. 6. Evaluate project management and industrial feasibility.							
Course Outcomes	After completing the course, students will be able to: 1. Explain fundamentals of process economics and costing. 2. Estimate fixed and variable costs of a project. 3. Evaluate profitability using standard economic criteria. 4. Apply project scheduling and budgeting techniques. 5. Analyse financial and risk aspects of projects. 6. Assess feasibility of chemical engineering projects.							

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	1	-	1	1	-	-	-	1	-	1
CO2	3	3	2	1	2	-	-	-	-	-	-	1
CO3	2	3	3	2	3	-	1	-	-	1	1	2
CO4	1	2	3	3	3	1	1	1	-	1	1	2
CO5	1	2	3	3	3	2	3	1	1	2	2	3
CO6	-	1	1	-	1	3	3	3	1	3	1	3

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

Unit No.	Course Content	Hours
I	**Introduction to Process Economics:** Significance of process economics in engineering design, Scales of Production, Selection of Plant Capacity, Plant Location. Availability of Raw Materials, Energy Gestation Period. Expansion, Diversification and Obsolescence.	**05**
II	**Cost Estimation and Cost Indices:** Factors Affecting Investment and Production Cost. Capital Investment, Fixed Investment and Working Capital. Estimating Equipment Cost by 6/10 Factor Rule Method of Estimating Capital Investment. Different Costs Involved in Total Product Cost. Computer Atomization in Costing	**06**
III	**Depreciation and Profitability Evaluation:** Types of Depreciation, Service Life, Salvage Value, Present Value. Methods of Determining Depreciation, Causes of Obsolescence and Inadequacy, Types of Taxes and Tax Returns. Types of Insurance and Legal Responsibility, Mathematical Methods of Profitability Evaluation, Cash Flow Diagram. Break Even Analyses, Balance Sheet, Pricing Issue Method and Income Statement.	**08**
IV	**Project Engineering and Management:** Project conception and definition, Project life cycle and documentation, Organization, Project Planning, CPM and PERT Techniques, Resource allocation and budgeting	**06**
V	**Plant Design and Layout Economics:** Factors affecting plant location and layout, Design of process flow diagrams and equipment layout, Material handling and storage economics, Optimization of plant design and safety considerations	**07**
VI	**Industrial Feasibility and Case Studies:** Technical, economic, and environmental feasibility, Risk assessment and decision-making, Case studies on process cost estimation and project evaluation, Project economics in sustainable and green technologies	**07**
Reference Books		
1.	Peters, M.S., Timmerhaus, K.D., & West, R.E. (2003). Plant Design and Economics for Chemical Engineers (5th ed.). McGraw-Hill, New York.	
2.	Seider, W. D., Seader, J. D., & Lewin, D. R. (2017). Product and Process Design Principles: Synthesis, Analysis, and Evaluation. Wiley.	
3.	Ulrich, G.D., & Vasudevan, P.T. (2004). Chemical Engineering Process Design and Economics: A Practical Guide. CRC Press, Boca Raton.	
4.	Vilbrandt, F.C., & Dryden, C.E. (2009). Chemical Engineering Plant Design. CBS Publishers, New Delhi.	
5.	Towler, G., & Sinnott, R.K. (2012). Process Design Principles: Synthesis, Analysis and Evaluation (2nd ed.). Elsevier, Oxford.	

Year, Program, Semester	Final Year B. Tech. (Chemical Engineering), Part IV, Semester VIII							
Course Code	PEC421.5							
Course Category	Program Elective Course (Online)							
Course title	**Program Elective-III: Introduction to Energy Technology (Online) (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)	PCC212, PCC221, PCC222, PCC224							
Course Rationale	Energy technology is central to chemical engineering practice, particularly in process industries where energy conversion, efficiency, sustainability, and environmental compliance are critical. This course introduces students to conventional and emerging energy technologies, energy conversion systems, and sustainability concepts. It builds foundational awareness required for careers in process industries, energy auditing, CHP systems, renewable energy, and decarbonization initiatives.							
Course Objectives	The course teacher will ensure to: 1. Introduce global and Indian energy resources patterns. 2. Explain industrial energy conversion technology principles. 3. Describe conventional and renewable energy systems. 4. Identify energy efficiency opportunities in industries. 5. Interpret environmental impacts of energy utilization. 6. Develop awareness of sustainable emerging energy technologies.							
Course Outcomes	After completing the course, students will be able to: 1. Explain global and national energy scenario trends. 2. Describe working of major energy conversion systems. 3. Compare conventional and renewable energy technologies. 4. Identify energy efficiency measures in process industries. 5. Interpret environmental impacts of energy production. 6. Outline emerging sustainable energy technologies relevance.							

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	1	-	-	-	2	2	1	-	-	-	2
CO2	3	2	1	1	1	1	1	-	-	-	-	1
CO3	2	3	-	1	-	2	3	1	-	-	-	2
CO4	3	2	2	1	1	2	3	-	-	-	1	2
CO5	2	2	-	1	-	3	3	2	-	-	-	2
CO6	2	1	-	-	-	2	3	1	-	-	-	3

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

Unit No.	Course Content	Hours
I	**Energy Scenario and Fundamentals:** Energy statistics in India and world, Energy Security, Energy Strategy for the Future, Kyoto Protocol, Global warming, Proximate and ultimate analysis of fuels, Calorific value; Specification and testing of petroleum fuels	7
II	**Conventional Energy Technologies:** Fossil fuels: coal, petroleum, natural gas, Thermal power plants – basic working principles, Coal-origin, classification, Carbonization; Manufacture of coke and recovery of by-products; Coal gasification,	6
III	**Renewable Energy Technologies**- Solar energy (thermal and PV basics), Nuclear energy: Fission and fusion reactions; Nuclear reactors for power generation. Wind energy fundamentals, Biomass and bioenergy, Hydrogen production, storage and use, geothermal overview, OTEC and MHD; Energy from biomass	6
IV	**Energy Conversion Systems:** Steam turbines and gas turbines – concept overview, Combined Heat and Power (CHP) systems, Economic Incentives for Further CHP systems, Technical Potential for Further CHP systems., Fuel cells – basic principles	8
V	**Energy Efficiency in Process Industries:** Energy use in chemical plants, Waste heat recovery concepts , Heat integration basics, Energy conservation opportunities	6
VI	**Sustainability and Emerging Energy Technologies:** Environmental impacts of energy use, Energy audits ,Carbon footprint and decarbonization, Hydrogen energy economy, Energy storage technologies overview	6
Text Books		
1.	Brame, J. S. S. (1914). Fuel: Solid, Liquid and Gaseous. Edward Arnold Publishers Ltd.	
2.	Sarkar, S. (2009). Fuels and Combustion (3rd ed.). Orient Longman Ltd.	
3.	Nelson, W. L. (1958). Petroleum Refining Engineering. McGraw-Hill Book Co.	
Reference Books		
1.	Kenny, W. F. (1984). Energy Conservation in the Process Industries. Academic Press Inc. (London) Ltd.	
2.	Bureau of Energy Efficiency. (2015). Guide Book for National Certification Examination for Energy Managers and Energy Auditors (4th ed.). Government of India.	
3.	Balasubramanian, P. (2003). Energy Auditing Made Simple. Bala Consultancy Services Publishers.	
4.	Boustead, N., & Hancock, G. F. (1979). Handbook of Industrial Energy Analysis. Ellis Horwood Ltd., Chichester (UK).	
5.	Turner, W. C. (2001). Energy Management Handbook. John Wiley & Sons.	
	Useful web links	
1.	https://www.energy.gov/eere/fuelcells/energy-education-links	

Year, Program, Semester	Final Year B. Tech. (Chemical Engineering), Part IV, Semester VIII							
Course Code	PEC422.1							
Course Category	Program Elective Course (Online)							
Course title	**Program Elective–IV: Introduction to Cement Technology(Online) (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)	PCC212, PCC221, PCC312, ESC211							
Course Rationale	Cement technology is a critical industrial domain where chemical and process engineering principles intersect with materials science and environmental management. This course introduces students to the raw materials, chemistry, manufacturing processes, quality control, and environmental aspects of cement production. By linking theoretical concepts with industrial practice, students will gain the ability to understand process optimization, emission control, energy efficiency, and sustainability challenges faced in cement plants. It prepares students for careers in cement manufacturing, construction materials, process design, and environmental management.							
Course Objectives	The course teacher will ensure to: 1. Explain cement chemistry and raw material properties. 2. Detail manufacturing processes and plant operations. 3. Apply mass and energy balance principles. 4. Analyse equipment design, layout, and control. 5. Evaluate safety, energy, and environmental aspects. 6. Discuss modern and sustainable cement technologies.							
Course Outcomes	After completing the course, students will be able to: 1. Explain cement chemistry principles and material characteristics. 2. Describe cement manufacturing stages and plant operations. 3. Apply mass and energy balances in cement. 4. Analyse cement plant equipment, layout and control. 5. Evaluate safety, energy and environmental industry issues. 6. Outline modern sustainable cement production technologies.							

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	1	-	-	1	2	-	-	1	-	1
CO2	3	3	2	1	2	1	2	-	-	-	-	1
CO3	2	3	3	2	3	1	2	-	-	1	1	2
CO4	1	2	3	3	3	2	3	1	-	1	2	2
CO5	1	2	3	3	3	3	3	1	1	2	2	3
CO6	-	1	1	-	1	2	3	2	1	3	1	3

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

Unit No.	Course Content	Hours
I	**Introduction to Cement and Its Raw Materials**: History and importance of cement industry, Classification and types of cement, Raw materials: limestone, clay, gypsum, and additives, Chemical composition and mineralogical phases of clinker	**04**
II	**Cement Manufacturing Process:** Dry, wet, semi-dry, and semi-wet processes, Process flow diagrams and process description, Unit operations in crushing, grinding, mixing, and blending, Role of kiln systems and energy considerations	**07**
III	**Kiln Operation and Clinker Formation:** Chemistry of reactions in kiln (calcination, clinkerization), Heat transfer and mass balance in rotary kilns, Clinker cooling and handling systems, Process control and instrumentation in kiln operation	**07**
IV	**Cement Grinding, Storage, and Quality Control:** Ball mills, vertical roller mills, and grinding efficiency, Cement storage and packing systems, Chemical and physical testing of cement (IS/ASTM standards), Quality assurance and statistical process control	**07**
V	**Environmental Management and Energy Conservation:** Air pollution in cement industry: sources and control measures, Dust collection, gas cleaning, and waste heat recovery, CO_2 emission reduction and carbon capture, Alternative fuels, raw materials, and green cements	**07**
VI	**Case Studies and Future Trends:** Case studies on process optimization and energy audits, Advances in low-carbon cements and geopolymer cements, Digital transformation and Industry 4.0 in cement plants, Mini project presentation: "Innovation in Cement Manufacturing"	**07**
Reference Books		
1.	Hewlett, P.C. (2019). Lea's Chemistry of Cement and Concrete (5th ed.). Butterworth-Heinemann (Elsevier), Oxford.	
2.	Duda, W.H. (2010). Cement Data Book: International Process Engineering in the Cement Industry. Bauverlag, Wiesbaden.	
3.	Taylor, H.F.W. (1997). Cement Chemistry (2nd ed.). Thomas Telford Publishing, London.	
4.	Peray, K.E., & Waddell, J.J. (1986). The Rotary Cement Kiln. Chemical Publishing Co., New York.	
5.	Sathanathan, M., & Venkateswaran, D. (2016). Cement Technology: Theory and Practice. New Age International, New Delhi.	

Year, Program, Semester	Final Year B. Tech. (Chemical Engineering), Part IV, Semester VIII							
Course Code	PEC422.2							
Course Category	Program Elective Course (Online)							
Course title	**Program Elective–IV: Introduction to Pulp and Paper Technology(Online) (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)	BSC211, PCC222, PCC313							
Course Rationale	This course introduces the pulp and paper technology. It covers the manufacturing of paper and pulping processes. The course emphasizes the significance of testing and evaluation methods of paper.							
Course Objectives	The course teacher will ensure to: 1. Discuss global pulp and paper industry significance. 2. Detail raw materials used in paper manufacturing. 3. Explain chemical and mechanical pulping processes. 4. Illustrate the integrated paper manufacturing process. 5. Demonstrate pulp and paper testing methods. 6. Describe biological applications in paper production.							
Course Outcomes	After completing the course, students will be able to: 1. Discuss paper industry importance and global applications. 2. Describe characteristics of paper-making raw materials. 3. Analyse unit operations in diverse pulping processes. 4. Explain integrated paper manufacturing process steps. 5. Execute testing and evaluation of paper products. 6. Identify biological applications in paper production.							

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	2	1	-	-	-	1	-	-	-	-	1
CO3	3	1	2	-	-	2	1	-	-	-	-	1
CO4	3	1	-	-	-	2	2	-	-	-	-	-
CO5	3	2	2	-	-	-	2	-	-	-	-	1
CO6	3	1	1	-	-	-	2	-	-	-	-	1

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

Unit No.	Course Content	Hours
I	**Introduction:** Importance of paper industry, historical background of paper making, development of paper industry in India, Importance of paper, definitions of pulp, paper, and paperboard.	**07**
II	**Raw materials and their preparation:** Classification of fibres, characteristics and composition of some important vegetable fibers (hard woods, softwoods, bagasse, straws, rags and paper stock), Wood preparation – pulp wood measurement, barking, chipping, screening and conveying of chips).	**07**
III	**Pulping processes:** Mechanical pulping, alkaline pulping (Soda and Kraft), sulfite pulping, semi-chemical pulping, recovery of cooking chemicals from spent cooking liquors, Bleaching agents, bleaching methods – single stage and multistage bleaching.	**06**
IV	**Manufacture of paper:** Beating and refining, sizing and loading (filling), Paper machines (Fourdrinier and Cylinder), making of paper – forming section, press section, dryer section, calendaring section.	**06**
V	**Testing of paper:** Testing and evaluation of pulp, various properties of pulp and paper and their testing, Different types and uses of papers and paper boards, composition, method of making different types of papers and boards.	**07**
VI	**Biological applications:** Environment friendly technologies for the pulp and paper industry, need, Chemical applications. Biological applications to pulp and paper processing, bio-bleaching of pulps.	**06**
	Text Books	
1.	Britt, K. W. (1970). Handbook of Pulp and Paper Technology. Van Nostrand Reinhold, New York.	
2.	MacDonald, R. G. (1969). Pulp and Paper Manufacture. (Vol I to III, 2nd Ed.). McGraw Hill, New York.	
3.	Young, R.A. & Akhtar, M. (1998). Environment Friendly Technologies for Pulp and Paper Industry. John Wiley and Sons, Inc., New York.	
4.	Rydholm, S. A. (1965). Pulping Process. Interscience Publishers, USA.	
	Reference Books	
1.	Casey, J. P. (1979). Pulp and Paper Chemistry and Chemical Technology (3rd ed.). Wiley Interscience, New York.	
2.	Kocurek, M. J. & Stevens, F. (1983) Pulp and Paper Manufacture. Tappi Publication.	
3.	Mark, R.E. (1983). Handbook of Physical and Mechanical Testing of Paper and Board (Vol.I & Vol. II). Marcel Dekker Inc.	
4.	Sjostrom, E. (1993). Wood Chemistry: Fundamentals and Applications (2nd ed.). Academic Press.	
5.	Libby, C. E. (1962). Pulp and Paper Science and Technology. McGraw-Hill, New York.	
	Useful web links	
1.	https://nptel.ac.in/courses/103107082	
2.	https://www.youtube.com/watch?v=YkmPi7T8TXA	

Year, Program, Semester	Final Year B. Tech. (Chemical Engineering), Part IV, Semester VIII							
Course Code	PEC422.3							
Course Category	Program Elective Course (Online)							
Course title	**Program Elective–IV: Introduction to Sugar and Alcohol Technology (Online) (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)	PCC224, PCC212, PCC311, PCC321, PCC312							
Course Rationale	This course provides an introduction to sugar and alcohol production technologies, emphasizing process operations, fermentation, sustainability, and industrial applications**,** preparing students for careers inagro-based process industries and bio energy sectors**.**							
Course Objectives	The course teacher will ensure to: 1. Discuss global and Indian sugar industry significance. 2. Explain sugar chemistry and analytical processing methods. 3. Detail unit operations in sugar manufacturing processes. 4. Explain industrial fermentation and alcohol production principles. 5. Discuss byproduct utilization and environmental sustainability. 6. Communicate emerging trends in bio-ethanol and renewables.							
Course Outcomes	After completing the course, students will be able to: 1. Explain sugar and alcohol industry global importance. 2. Apply sugar chemistry knowledge to industrial processing. 3. Describe integrated sugar manufacturing using flow diagrams. 4. Explain industrial fermentation and ethanol production steps. 5. Analyse byproduct utilization and environmental sustainability issues. 6. Evaluate renewable energy roles of distillery processes.							

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	1	-	-	-	1	1	-	-	-	-	1
CO2	3	2	1	-	-	-	-	-	-	-	-	-
CO3	2	2	3	-	1	-	-	-	-	-	-	-
CO4	2	2	2	1	1	-	-	-	-	-	-	-
CO5	1	2	1	2	-	1	3	2	-	-	-	-
CO6	1	2	1	2	-	1	3	1	-	-	-	1

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

Unit No.	Course Content	Hours
I	**Overview of Sugar and Alcohol Industries:** History and development of sugar and alcohol industries, Global and Indian scenario, Raw materials: sugarcane, sugar beet, molasses, grains, Structure of sugar mills and distilleries, Role of sugar and alcohol industries in rural economy.	**06**
II	**Chemistry and Properties of Sugars:** Chemical structure of sucrose, Physical and chemical properties, on-sugars and impurities, Inversion of sugar, Analytical methods for sugar analysis (Brix, Pol, purity).	**07**
III	**Sugar Manufacturing Process:** Extraction of juice: milling and diffusion, Juice clarification and liming, Evaporation and concentration, Crystallization of sugar, Centrifugation and drying.	**07**
IV	**Alcohol and Ethanol Production Technology:** Fermentation principles, Yeast and microorganisms, Batch and continuous fermentation, Distillation and rectification. Dehydration of alcohol.	**06**
V	**By-products, Waste Utilization, and Environmental Aspects:** Molasses, bagasse, press mud, Cogeneration from bagasse, Spent wash treatment, Zero liquid discharge (ZLD) concepts, Environmental regulations and sustainability.	**07**
VI	**Bio ethanol, Energy, and Emerging Trends:** Bio ethanol as renewable fuel, Blending of ethanol with petrol, Second-generation bio ethanol, Bio refineries and circular economy, Future trends in sugar and alcohol industries	**06**
Text Books		
1.	Hugot, E. (1986). Handbook of Cane Sugar Engineering (3rd ed.). Amsterdam: Elsevier.	
2.	Meade, G. P., & Chen, J. C. P. (1977). Cane Sugar Handbook (10th ed.). New York: Wiley.	
Reference Books		
1.	Jacques, K. A., Lyons, T. P., & Kelsall, D. R. (2003). The Alcohol Textbook (4th ed.). Nottingham: Nottingham University Press.	
2.	Stanbury, P. F., Whitaker, A., & Hall, S. J. (2016). Principles of Fermentation Technology (3rd ed.). Oxford: Elsevier.	
3.	Rao, D. G. (2010). Introduction to Chemical Engineering (2nd ed.). New Delhi: Tata McGraw-Hill.	
4.	Shuler, M. L., & Kargi, F. (2017). Bioprocess Engineering: Basic Concepts (3rd ed.). Boston: Pearson.	
5.	Luque, R., Campelo, J. M., & Clark, J. H. (2011). Handbook of Biofuels Production. Cambridge: Woodhead Publishing.	
Useful web links		
1.	https://nptel.ac.in/courses/103107082	
2.	http://elearn.psgcas.ac.in/nptel/courses/video/103103220/lec9.pdf	
3.	http://acl.digimat.in/nptel/courses/video/102105058/lec27.pdf	

Year, Program, Semester	Final Year B. Tech. (Chemical Engineering), Part IV, Semester VIII						
Course Code	PEC422.4						
Course Category	Program Elective Course (Online)						
Course title	**Program Elective–IV: Introduction to Dyes and Pigments Technology (Online) (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)	BSC211, BSC221, PCC313, PCC311						
Course Rationale	Dyes and pigments play a vital role in textile, polymer, paint, printing, food, and pharmaceutical industries. Chemical engineers contribute to synthesis, processing, formulation, scale-up, and environmental management of dye and pigment manufacturing. This course introduces fundamental chemistry, classification, production methods, and industrial applications of dyes and pigments. The curriculum is aligned with introductory color chemistry and industrial coloration courses offered globally, emphasizing industrial relevance, sustainability, and regulatory aspects.						
Course Objectives	The course teacher will ensure to: 1. Introduce fundamentals and importance of industrial colorants. 2. Explain chemistry and classification of major dyes. 3. Detail manufacturing processes for dyes and pigments. 4. Identify colorant applications in various industrial sectors. 5. Discuss environmental and safety manufacturing concerns. 6. Showcase modern sustainable coloration technology trends.						
Course Outcomes	After completing the course, students will be able to: 1. Classify dyes and pigments by structure applications. 2. Explain chemistry principles of industrial coloration processes. 3. Describe industrial manufacturing of dyes and pigments. 4. Select colorants for specific diverse industrial applications. 5. Interpret environmental impacts and pollution control measures. 6. Outline sustainable technologies in the coloration industry.						

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	1	-	-	-	1	-	-	-	-	-	1
CO2	3	2	-	1	1	-	-	-	-	-	-	1
CO3	3	2	1	1	1	1	1	-	-	-	-	1
CO4	3	2	2	1	1	1	1	-	-	-	-	1
CO5	2	2	-	1	-	3	3	2	-	-	-	2
CO6	2	1	-	-	-	2	3	1	-	-	-	3

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

Unit No.	Course Content	Hours
I	**Introduction and Industrial Significance:** History and development of dyes and pigments; difference between dyes and pigments based on composition, solubility, and application; role and importance in textile, paint, plastics, printing, and leather industries; overview of Indian and global market trends, production, and industrial relevance.	6
II	**Classification and Chemistry of Dyes:** Classification of dyes based on chemical structure including Azo, Anthraquinone, Indigoid, and Triphenylmethane dyes; classification based on application such as Reactive, Direct, Vat, Disperse, Acid, and Basic dyes; basic principles of dye–fiber interaction including bonding mechanisms and factors affecting dye uptake.	6
III	**Pigments and Their Properties:** Introduction to inorganic pigments such as titanium dioxide (TiO_2), iron oxides, and chromium compounds; organic pigments including phthalocyanines and azo pigments; study of color properties, opacity, tinting strength, durability, and stability under different environmental conditions.	7
IV	**Manufacturing Processes:** General steps involved in dye synthesis including raw material selection, reaction, separation, and finishing; comparison of batch and continuous production methods; basic process flow of selected dyes and pigments; role of chemical engineers in process scale-up, optimization, and process control.	8
V	**Applications in Industries:** Textile coloration processes including dyeing and printing techniques; use of dyes and pigments in paints and coatings; applications in plastics and printing inks; performance requirements, quality parameters, and selection criteria for industrial applications.	6
VI	**Environmental and Sustainable Technologies:** Effluent generation and characteristics in dye and pigment industries; pollution control methods and wastewater treatment approaches; eco-friendly dyes, biodegradable alternatives, and green chemistry concepts; regulatory guidelines, environmental norms, and safety considerations in manufacturing and handling.	6
Text Books		
1.	Christie, R. M. (2015). Colour Chemistry. Royal Society of Chemistry.	
2.	Zollinger, H. (2003). Color Chemistry: Syntheses, Properties, and Applications of Organic Dyes and Pigments (3rd ed.). Wiley-VCH.	

Reference Books	
1.	Herbst, W., & Hunger, K. (2004). Industrial Organic Pigments: Production, Properties, Applications (3rd ed.). Wiley-VCH.
2.	Shore, J. (2002). Colorants and Auxiliaries: Organic Chemistry and Application Properties (Vol. 1). Society of Dyers and Colourists.
3.	Peters, A. T., & Freeman, H. S. (1995). Colour Chemistry: The Design and Synthesis of Organic Dyes and Pigments. Elsevier.
4.	Allen, R. L. M. (1971). Colour Chemistry. Thomas Nelson and Sons.

Year, Program, Semester	Final Year B. Tech. (Chemical Engineering), Part IV, Semester VIII						
Course Code	PEC422.5						
Course Category	Program Elective Course (Online)						
Course title	**Program Elective–IV: Introduction to Pharmaceutical Technology(Online) (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)	BSC211, BSC221, PCC212, PCC311, PCC221						
Course Rationale	The pharmaceutical industry is one of the largest employers of chemical engineers, where they contribute to drug manufacturing, formulation, process design, scale-up, quality assurance, and regulatory compliance. This course introduces students to the fundamentals of pharmaceutical technology, including drug development, dosage form design, manufacturing processes, quality systems, and regulatory aspects. Emphasis is placed on applying chemical engineering principles to pharmaceutical production and understanding how product quality is built into processes. The course prepares graduates for roles in pharmaceutical manufacturing, formulation development, quality assurance, and advanced studies.						
Course Objectives	The course teacher will ensure to: 1. Explain pharmaceutical dosage forms and delivery systems. 2. Describe physicochemical properties in drug formulation. 3. Apply engineering principles to pharmaceutical manufacturing. 4. Analyze unit operations for diverse dosage forms. 5. Interpret regulatory requirements and quality control. 6. Relate product design with industrial scale-up concepts.						
Course Outcomes	After completing the course, students will be able to: 1. Describe pharmaceutical dosage forms and delivery systems. 2. Explain physicochemical drug properties for formulation. 3. Apply engineering principles to pharmaceutical manufacturing. 4. Analyse unit operations in pharmaceutical production. 5. Evaluate quality control and regulatory requirements. 6. Design basic manufacturing flow sheet for pharmaceuticals.						

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	1	1	-	1	-	-	-	1	-	2
CO2	3	2	1	1	-	-	-	-	-	1	-	2
CO3	3	3	2	1	1	-	1	-	-	1	-	2
CO4	3	3	2	2	1	-	1	-	-	1	-	2
CO5	2	2	2	1	1	3	1	2	-	1	-	2
CO6	3	2	3	2	2	2	1	1	1	2	2	2

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

Unit No.	Course Content	Hours
I	**Introduction to Pharmaceutical Technology:** Overview of pharmaceutical industry, Drug discovery and development pipeline, Classification of dosage forms, Routes of drug administration, Role of chemical engineers in pharmaceutical manufacturing	**06**
II	**Physicochemical Properties of Drugs & Excipients:** Solubility and dissolution, pKa and ionization, Partition coefficient, Polymorphism and crystallinity, Drug–excipient compatibility	**06**
III	**Pharmaceutical Unit Operations:** Size reduction and size enlargement, Mixing and blending, Drying techniques, Filtration and centrifugation, Granulation	**07**
IV	**Solid, Liquid & Semisolid Dosage Form Manufacturing:** Tablets and capsules, Syrups, suspensions, emulsions, Ointments, creams, gels, Basic formulation principles	**07**
V	**Quality Control, GMP & Regulatory Aspects:** Quality control tests, Good Manufacturing Practices (GMP), Validation and documentation, Stability studies, Introduction to regulatory agencies	**07**
VI	**Pharmaceutical Process Design & Scale-Up:** Process flow diagrams, Scale-up principles, Introduction to Quality by Design, Process analytical technology (PAT), Case study of a pharmaceutical product	**06**
Text Books		
1.	Aulton, M. E., & Taylor, K. M. G. (2018). Aulton's Pharmaceutics: The Design and Manufacture of Medicines (5th ed.). Elsevier.	
2.	Sambamurthy, K. (2010). Pharmaceutical Engineering. New Age International.	
3.	Hickey, A. J., & Ganderton, D. (2001). Pharmaceutical Process Engineering (2nd ed.). CRC Press.	
4.	Adeboye, B. A. (2020). Remington: The Science and Practice of Pharmacy (23rd ed.). Pharmaceutical Press.	
Reference Books		
1.	Yalkorsky, S.H. & Swarbrick, J. (1975). Drug and pharmaceutical Science (Volume I, II, III, IV, V, VI, and VII).	
2.	Ansel, H. C., Stoklosa, M. J., & Allen, L. V. (2016). Ansel's Pharmaceutical Calculations (15th ed.). Lippincott Williams & Wilkins.	
3.	Lachman, L., Lieberman, H. A., & Kanig, J. L. (2013). The Theory and Practice of Industrial Pharmacy (4th ed.). CBS Publishers.	

Year, Program, Semester	Final Year B. Tech. (Chemical Engineering), Part IV, Semester VIII						
Course Code	IKS421						
Course Category	Program Specific Indian Knowledge System (IKS)(Online)						
Course title	**Traditional Sustainable Indian Chemical Technologies (Online) (Theory)**						
Teaching Scheme and Credits	**L**	**T**	**P**	**Total Contact Hours**	**Total Credits**		
	02	-	-	02	02		
Evaluation Scheme	**ISE**	**ESE**		**IOE**	**IPE**	**EOE**	**EPE**	**Total**
	30	70		-	-	-	-	100
Pre-requisites (if any)	PCC212, PCC221, PCC224, PCC311, PCC312, PCC321						
Course Rationale	India has a rich heritage of scientific knowledge rooted in its ancient texts and traditional practices. This course explores the chemical and process engineering foundations implicit in traditional Indian technologies—such as metallurgy, dyes, food processing, fermentation, distillation, and environmental management. It bridges ancient wisdom with modern sustainability principles, encouraging learners to recognize indigenous innovations as early examples of green and circular technologies. Through this course, students will develop an interdisciplinary appreciation of India's contribution to chemical sciences and engineering, while also gaining insights into how such knowledge can inform modern sustainable practices and process innovations.						
Course Objectives	The course teacher will ensure to: 1. Explain origins of Indian chemical scientific thought. 2. Detail traditional chemical and metallurgical technologies. 3. Describe indigenous material and process innovations. 4. Examine eco-friendly and sustainable traditional practices. 5. Compare ancient and modern engineering principles. 6. Discuss ethical and environmental wisdom in IKS.						
Course Outcomes	After completing the course, students will be able to: 1. Explain origins of Indian scientific chemical thought. 2. Describe traditional chemical and metallurgical technologies. 3. Identify indigenous materials and process innovations. 4. Analyse eco-friendly sustainable traditional engineering practices. 5. Compare ancient and modern engineering concepts. 6. Interpret ethical environmental values in Indian knowledge.						

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	-	-	-	2	3	2	-	1	-	2
CO2	2	2	-	1	-	2	3	-	-	-	-	1
CO3	1	3	2	2	2	-	3	-	-	-	-	2
CO4	1	2	3	2	2	2	3	1	-	1	-	2
CO5	1	2	3	2	2	3	3	2	1	2	2	3
CO6	-	-	1	-	1	1	3	2	2	3	1	3

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

Unit No.	Course Content	Hours
I	**Introduction to Indian Knowledge Systems and Science**: Overview of Indian Knowledge Systems and NEP2020 framework, Scientific and philosophical basis of traditional Indian thought, Contributions of ancient texts: Rasashastra, Vedas, Sushruta Samhita, Charaka Samhita, Understanding "Science as holistic practice" in Indian tradition	**04**
II	**Early Indian Chemistry and Metallurgical Traditions**: Development of metallurgy: iron, steel (Wootz), copper, zinc, and alloys, Smelting, extraction, and casting processes, Corrosion resistance, surface finishing, and ancient furnaces, Indigenous glass, ceramics, and cement technologies	**05**
III	**Indigenous Materials, Dyes, and Pigments**: Natural dyes and pigments: indigo, madder, turmeric, henna, Traditional soap, cosmetics, and perfume making, Alkali, acid, and salt preparation from natural resources, Chemical principles behind color stability and extraction methods	**05**
IV	**Traditional Processes in Food, Fermentation, and Distillation:** Ancient fermentation and distillation techniques (sura, vinegar, curd, ghee), Traditional food preservation and dehydration methods, Indigenous nutraceuticals and Ayurvedic formulations, Biochemical relevance and modern analogies (bioprocess, downstream ops.)	**04**
V	**Water, Waste, and Energy Management in Ancient India:** Traditional water harvesting and purification systems, Waste management, composting, and biogas-like concepts, Sustainable energy systems: charcoal, lime kilns, biofuels, Philosophical and environmental ethics embedded in these practices	**04**
VI	**Integrating IKS into Modern Chemical Engineering:** Linking ancient technologies to green engineering principles, Modern research inspired by traditional knowledge (e.g., herbal catalysts, green solvents), IKS-based entrepreneurship and innovation opportunities, Project presentations: "Rediscovering Traditional Chemical Practices"	**04**
Reference Books		
1.	Subbarayappa, B.V. (2001). Indian Tradition of Chemistry and Chemical Technology. Indian National Science Academy, New Delhi.	
2.	Dhar, P. (2023). Indian Knowledge Systems: Theory and Practice. AICTE & CBSE Publication, New Delhi.	

3.	Dandekar, N. (2018). Science and Technology in Ancient India. National Book Trust, India.
4.	Joseph, G.G. (2016). The Crest of the Peacock: Non-European Roots of Mathematics and Science. Princeton University Press.
5.	Agrawal, D.P. (2000). Ancient Metal Technology and Archaeology of South Asia: A Pan-Asian Perspective. Aryan Books International, New Delhi.

Year, Program, Semester	Final Year B. Tech. (Chemical Engineering), Part IV, Semester VIII							
Course Code	PSI424							
Course Category	Project Seminar Internship(Online)							
Course title	**Plant Design & Case Studies(Online) (Theory)**							
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	100
Pre-requisites (if any)	PCC212, PCC224, PCC312, PCC322							
Course Rationale	Chemical plant design represents the culmination of all prior engineering learning—integrating thermodynamics, transport phenomena, reaction engineering, and process economics into a coherent, safe, and sustainable industrial system. This course introduces students to concepts, methodology, and practical aspects of process and plant design. Using industrial case studies, students learn decision-making in design, safety, sustainability, and economic optimization. It builds the foundation for capstone projects and professional engineering practice.							
Course Objectives	The course teacher will ensure to: 1. Explain fundamental chemical plant design principles. 2. Detail process development stages and design hierarchy. 3. Analyse equipment selection and plant layout considerations. 4. Evaluate safety, environmental, and economic aspects. 5. Facilitate analysis of real industrial case studies. 6. Develop engineering problem-solving and decision-making skills.							
Course Outcomes	After completing the course, students will be able to: 1. Explain basic concepts of plant design. 2. Identify stages in process and plant design. 3. Interpret layout, equipment, and design data. 4. Analyse design decisions using safety and economics. 5. Evaluate real plant design case studies. 6. Present design case findings effectively.							

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	1	-	-	1	-	-	-	1	-	1
CO2	3	3	2	1	2	1	-	-	-	-	-	1
CO3	2	3	3	2	3	-	1	-	-	1	1	2
CO4	2	3	3	3	2	2	2	2	-	1	2	2
CO5	1	2	3	3	2	3	3	2	1	2	2	3
CO6	-	-	2	-	2	-	1	2	3	3	1	2

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

Unit No.	Course Content	Hours
I	**Introduction to Chemical Plant Design**: Definition, objectives, and scope of plant design, Process design vs. detailed design, Role of chemical engineer in plant design	**02**
II	**Design Methodology and Process Development**: Concept development and process selection, Flow sheet preparation and process optimization, Design hierarchy and iterative design approach	**03**
III	**Equipment and Layout Design:** Equipment selection criteria (reactors, heat exchangers, separators), Layout design: process, utility, and safety considerations, Piping and instrumentation diagrams (P&ID) basics	**03**
IV	**Safety, Environmental, and Economic Aspects**: Design for safety and hazard minimization, Environmental protection and sustainability in design, Economic evaluation: capital and operating cost estimation	**02**
V	**Case Studies in Process Design**: Case study 1: Distillation column and solvent recovery plant, Case study 2: Heat exchanger network design, Case study 3: Wastewater treatment plant	**02**
VI	**Presentation and Documentation**: Report preparation and design presentation format, Case study presentation by student groups, Learning reflection and industrial feedback discussion	**01**
Reference Books		
1.	Peters, M.S., Timmerhaus, K.D., & West, R.E. (2003). Plant Design and Economics for Chemical Engineers. McGraw-Hill, New York.	
2.	Sinnott, R.K., & Towler, G. (2020). Chemical Engineering Design: Principles, Practice and Economics of Plant and Process Design. Elsevier, Oxford.	
3.	Ulrich, G.D., & Vasudevan, P.T. (2004). Chemical Engineering Process Design and Economics: A Practical Guide. Prentice Hall, New Jersey.	
4.	Turton, R., Bailie, R.C., Whiting, W.B., & Shaeiwitz, J.A. (2012). Analysis, Synthesis, and Design of Chemical Processes. Prentice Hall, New Jersey.	

Year, Program, Semester	Final Year B. Tech. (Chemical Engineering), Part IV, Semester VIII							
Course Code	VEC421							
Course Category	Value Education Course(Online)							
Course title	**Professional Ethics(Online) (Theory)**							
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)	HSMEC111, HSMEC121, AEC211							
Course Rationale	This course aims to develop ethical awareness and professional responsibility among engineering graduates. In a world of rapid technological change and complex socio-environmental challenges, engineers must balance technical excellence with moral integrity, social accountability, and human values. The course sensitizes students to ethical frameworks, professional codes of conduct, workplace dilemmas, and decision-making processes to help them act responsibly as global engineers and leaders.							
Course Objectives	The course teacher will ensure to: 1. Explain the nature and scope of ethics. 2. Identify ethical issues in engineering practice. 3. Apply ethical theories to real-world dilemmas. 4. Examine professional responsibilities and ethical codes. 5. Cultivate moral reasoning and decision-making skills. 6. Demonstrate ethical leadership and professional communication.							
Course Outcomes	After completing the course, students will be able to: 1. Explain fundamental concepts of ethics. 2. Identify ethical challenges in engineering practice. 3. Apply moral reasoning to resolve dilemmas. 4. Interpret professional codes and responsibilities. 5. Evaluate ethical dimensions in real situations. 6. Communicate ethical decisions effectively.							

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	1	-	-	-	2	2	3	-	1	-	1
CO2	2	2	-	1	-	3	2	3	-	-	-	1
CO3	1	3	1	2	1	2	2	3	-	1	-	2
CO4	1	2	2	2	-	2	2	3	-	1	-	2
CO5	1	2	3	2	1	2	2	3	1	2	2	3
CO6	-	-	1	-	1	-	2	2	3	3	1	2

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

Unit No.	Course Content	Hours
I	**Introduction to Ethics and Human Values**: Definition, scope, and importance of ethics, Relationship between values, morals, and ethics, Human values and their role in engineering	**02**
II	**Professionalism and Engineering Ethics:** Characteristics of a profession, Responsibilities of engineers toward society, employers, and peers, Role of professional bodies (e.g., IEEE, ASME, IEI)	**02**
III	**Ethical Theories and Decision-Making Models**: Utilitarianism, duty ethics, virtue ethics, Ethical decision-making frameworks, Case studies in engineering contexts	**02**
IV	**Workplace Ethics and Professional:** Conflict of interest, confidentiality, intellectual property rights, Ethics in research and publication, Harassment, discrimination, and whistleblowing	**02**
V	**Ethics in Emerging Technologies:** Ethical issues in AI, automation, biotechnology, and data security, Environmental ethics and sustainable responsibility, Globalisation and cultural diversity in ethics	**03**
VI	**Ethical Leadership and Communication:** Traits of ethical leaders, Team ethics and collaborative responsibility, Case presentations and role-play exercises	**02**
Reference Books		
1.	Harris Jr., C. E., Pritchard, M. S., Rabins, M. J. (2018). Engineering Ethics: Concepts and Cases. Cengage Learning, Boston.	
2.	Govindarajan, M., Natarajan, S., & Senthil Kumar, V.S. (2004). Engineering Ethics. Prentice Hall of India, New Delhi.	
3.	Fleddermann, C.B. (2011). Engineering Ethics. Pearson Education, New Jersey.	
4.	Martin, M.W., & Schinzinger, R. (2009). Introduction to Engineering Ethics. McGraw-Hill, New York.	
5.	Subramanian, R. (2015). Professional Ethics. Oxford University Press, New Delhi.	

Year, Program, Semester	Final Year B. Tech. (Chemical Engineering), Part IV, Semester VIII						
Course Code	PBL421						
Course Category	Project Based Learning						
Course title	**MDM based Mini Project**						
Teaching Scheme and Credits	**L**	**T**	**P**	**Total Contact Hours**		**Total Credits**	
	-	-	-	-		02	
Evaluation Scheme	**ISE**	**ESE**		**IOE**	**IPE**	**EOE**	**EPE**	**Total**
	-	-		50	-	50	-	100
Pre-requisites (if any)	Basics of unit processes and unit operations.						

***Note: MDM based Mini Project:** There is a pool of MDM programs with three different options namely Food Process Engineering, Artificial Intelligence and Machine Learning, and Piping Design Engineering. The students have to undergo Mini Project work relevant to the chosen MDM Program

The Equivalence for the Courses of Chemical Engineering at Final Year B. Tech. Chemical Engineering Semester VII and Semester VIII of pre-revised Program under the faculty of Science and Technology are as follows.

SEM – VII

Sr. No.	Final Year B. Tech Semester VII Pre-revised syllabus	Final Year B. Tech Semester VII Revised syllabus	Remark
1	Biochemical Engineering	-	Well taken care of in the Program Core Elective Pool.
2	Elective-I	-	Shift of semester.
3	-	Program Elective Course-II	Added a Program Core Elective.
4	Industrial Economics and Management	-	Well taken care of in the Open Elective Pool.
5	Process Equipment Design (Theory & Lab)	-	The title is changed with the semester shift.
6	Major Project-Phase I	-	Content revision.
7	Process Modelling and Simulation (Theory & Lab)	Process Modelling and Simulation (Theory & Lab)	Content Revision.
8	Internship II	-	Shifted to last semester.
9	Comprehensive Tests	-	Dropped out on account of reduction in course credits.
10	Audit Course V Introduction to Indian Constitution	-	Shifted to First year.
11		Green Technology & Sustainability	Newly added Credit course.
12	-	Piping & Instrumentation: Design & Drawing (Theory & Lab)	Content revision with shift of semester.
13	-	Transport Phenomena	Content revision with shift of semester.
14	-	Open Elective- II	Newly introduced.
15	-	Major Project Lab	Newly introduced.
16	-	MDM based Industry Internship	Newly introduced as a part of MDM

* The MDM based industry Internship to be completed during winter/summer vacation slots 4th Semester onwards, before 7th Semester commencement.

SEM – VIII

Sr. No.	Final Year B. Tech Semester VIII Pre-revised syllabus	Final Year B. Tech Semester VIII Revised syllabus	Remark
1	Energy Resources and Utilization	-	Well taken care of in the Program Elective Pool.
2	Elective-II (Open Elective)	Program Elective –III (Online)*	Newly introduced.
3	Plant Design and Drawing (Lab)	Plant Design & Case Studies (Online)*	Content revision and mode change to online.
4	Special Chemical Technologies	-	Dropped out due to reduction in credits.
5	Transport Phenomena	-	Shifted to the previous semester with content revision.
6	Major Project-Phase II	Industrial Internship & Major Project Phase-II	Clubbed with Industrial internship.
7	Industrial Visits	-	Clubbed with Mini Projects.
8	Process Economics and Project Engineering	-	Well taken care under the Open Elective Pool.
9	Piping & Instrumentation Design and Drawing	-	Shifted to the previous semester.
10	Seminar	Plant Design & Case Studies (Online)	Mode is changed.
11	Audit Course VI Professional Ethics	Professional Ethics (Online)	Mode is changed and made it as a Credit Course.
12	-	Entire Semester Industrial Internship (Follow up by the Department)	Newly introduced.
13	-	Program Elective –IV (Online)	Newly introduced. Online mode.
14	-	Program Specific IKS (Traditional Sustainable Indian Chemical Technologies) (Online)	Newly introduced (Online Mode)
15	-	MDM Based Mini Project*	Newly introduced as a part of MDM

*MDM based Mini Project to be completed during 4th Semester to 8th Semester.