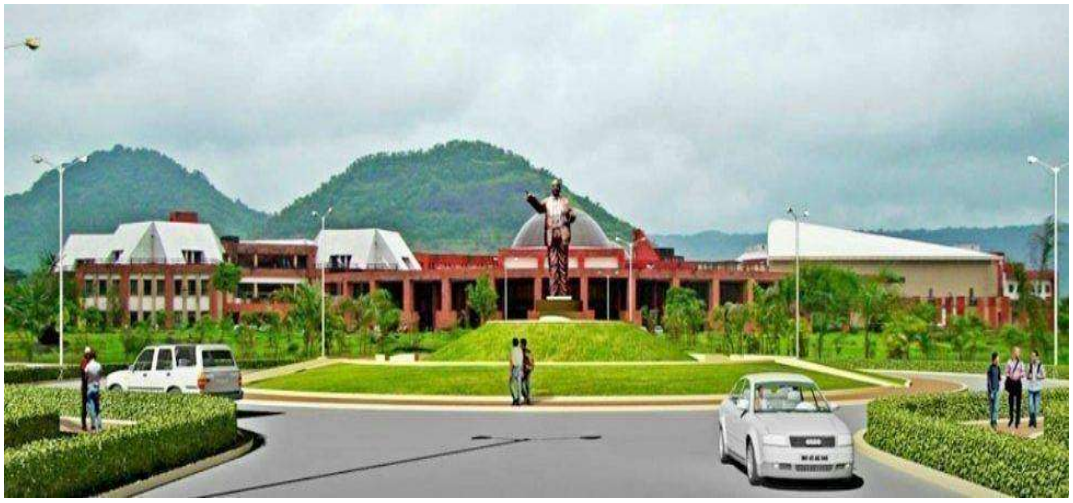
Dr. Babasaheb Ambedkar Technological University
(Under Maharashtra Act No. XXIX of 2014)
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POST GRADUATE CURRICULUM
FOR
CHEMICAL ENGINEERING
AS PER NEP-2020

WITH EFFECT FROM THE ACADEMIC YEAR 2023-24

Dr. Babasaheb Ambedkar Technological University, Lonere



M. Tech. Course Structure for Chemical Engineering as per NEP-2020

With effect from academic year 2023-24

Sem	Course Code	Course Title	L	T	P	Cr	Category
Sem-I	23U2507PC101	Advanced Momentum Transfer	3	1	-	4	PCC
	23U2507PC102	Advanced Reaction Engineering	3	1		4	PCC
	23U2507PC103	Thermodynamics of Phase Equilibria	3	-	-	3	PCC
	23U2507PE104	Program Elective - I A. Advanced Heat Transfer B. Conceptual Design of Chemical Processes C. Project Evaluation	3	-	-	3	PEC
	23U2507PE105	Program Elective - II A. Bioprocess Engineering B. Process Intensification C. Selected Topics in Heat Transfer	3	-	-	3	PEC
	23U2000RM106	Research Methodology	3	-	-	3	ELC
	23U2507PC107L	Computational Lab - I	-	-	2	1	PCC
	23U2507AU108	Stress Management with Yoga	2	-	-	-	Audit course
		Total	**20**	**2**	**2**	**21**	
Sem-II	23U2507PC201	Advanced Mass Transfer Operations	3	1	-	4	PCC
	23U2507PC202	Advanced Separation Techniques	3	1	-	4	PCC
	23U2507PE203	Program Elective - III A. Risk Analysis and Hazops B. Reactive Separations C. Pinch Technology	3	-	-	3	PEC
	23U2507PE204	Program Elective – IV A. Computer Control of Process Plants B. Steady State Process Simulation C. Energy Management	3	-	-	3	PEC
	23U2507PC205L	Computational Lab – 2	-	-	2	1	PCC
	23U2507MP206	Mini Project	-	-	4	2	ELC
	23U2507HM207	Project Management / Intellectual Property Rights	2	-	-	2	
	23U2507AE208	IKS Bucket A. History of Science and	2	-	-	2	IKS

		Technology in India B. Indian Art: Materials, Techniques and Artistic Practices C. Concepts and Applications in Engineering D. Humanities and Social Sciences					
	23U2507AU209	Disaster Management	2	-	-	-	Audit course
		Total	**18**	**2**	**6**	**21**	
Sem-III	24U2507PE301	Program Elective-V A. Optimization Methods for Chemical Processes B. Modern Analytical Techniques & Instrumentation C. Petroleum Technology	3	-	-	3	PEC
	24U2507OE302	Open Elective A. Student Psychology B. Strategic Management – The Competitive Edge C. Business Environment D. Hospitality Industry in Tourism	3	-	-	3	POC
	24U2507AU303	Environmental Studies	2	-	-	-	Audit course
	24U2507SE304	Seminar	-	-	4	2	ELC
	24U2507PR305	Project Work (Stage –I)	-	-	-	10	ELC
		Total	**9**	**-**	**-**	**18**	
Sem-IV	24U2507PR401	Project Work (Stage –II)	-	-	-	20	ELC
		Total	**-**	**-**	**-**	**20**	

SYLLABUS FOR SEMESTER-I

ADVANCED MOMENTUM TRANSFER

Course Outcomes: At the end of the course, the student will be able to:

CO1	Understand the analogous mechanism of momentum Transport for steady and unsteady flow.
CO2	Perform momentum balance for a given system at macroscopic and microscopic scale.
CO3	Solve the governing equations to obtain velocity profiles.
CO4	Model the momentum transport under turbulent conditions.

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	√	-	-	-	-	-	-	-
CO2	√	√	-	-	-	-	-	-
CO3	√	√	-	-	-	-	-	-
CO4	√	√	-	√	-	-	-	-

Detailed Syllabus:

Unit 1 and 2: Turbulent flow: basics, Reynolds average Navier-Stokes equations, closure problem, Boussinesque hypothesis, Prandtl mixing length theory, turbulence models, energy spectrum, turbulent boundary layer, and universal velocity profile.

Unit 3: Bernoulli's equation and its applications.

Unit 4–5: Gas-liquid and solid-liquid fluidized beds: Characteristics of particles, Principle of fluidization and mapping of various regimes, Two phase theory of fluidization, Bubbles in fluidized bed, Entrainment and Elutriation, Fast fluidized bed, Mixing, segregation and gas dispersion, Heat and mass transfer in fluidized bed, Solid-liquid fluidized bed and three phase fluidized bed, Design of fluidized bed reactors.

Textbooks / References:

1. Transport Phenomena, R. B. Bird, W. E. Stewart and E.N. Lightfoot, John Wiley, 1960.

2. Transport Phenomena – A Unified Approach, R.S. Brodkey and H.C. Hershey, McGraw Hill, 1988.

3. Momentum, Heat and Mass transfer, C.O. Bennet and J.E. Myers, McGraw Hill, 1993.

ADVANCED REACTION ENGINEERING

Course Outcomes: At the end of the course, the student will be able to:

CO1	Calculate reactor performance in situations where the observed reaction rate is significantly influenced by internal mass transfer in porous heterogeneous catalytic systems
CO2	Understand the energy balance and concentration profiles of multiphase reactors.
CO3	Estimate the performance of multiphase reactors in the situation such as temperature not uniform within the reactor and three phases are involved
CO4	Understand modern reactor technologies for mitigation of global warming

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	√	-	-	-	-	-	-	-

CO2	√	√	-	-	-	-	-	-
CO3	√	√	-	-	-	-	-	-
CO4	√	√	-	√	-	-	-	-

Detailed Syllabus:

Unit 1: Non elementary Kinetics Importance: Approximations for formulations of Rate laws, Formulations of Kinetic model. Effect of flow on conversions in Reactors: Semi-batch Reactors : Importance and examples of applications , Material Balance on Semi-batch Reactor, Multiple reaction in Semi-batch Reactors, Conversion vs Rate in Reactors, Use of POLYMATHS to solve the equations and understanding the profiles

Unit 2: Non-Isothermal reaction modeling in CSTR & Semi-Batch reactor: Energy Balance equations for CSTR, PFR and Batch reactors, Adiabatic operations Temperature conversion profiles in PFR, CSTR, Steady state tubular reactor with heat exchange, Need for Multi-staging CSTR with multiple stages: Exothermic and Endothermic Reaction with examples, CSTR with heat effects, Multiple reactions in CSTR and PFR with heat effects, Semi batch Reactors with heat exchange.

Unit 3: Design of PFR and Packed Bed Tubular Reactors: Radial and Axial mixing in Tubular reactors, Unsteady state in non-isothermal energy balance, CSTR, Energy balance in Batch Reactors, Volume of reactors calculations for non-isothermal reactors. Optimal Design of Reactors for Reversible exothermic reactions: Unsteady state non-isothermal reactor design, Adiabatic operation in batch, Heat effects in semi-batch Unsteady state operation. Auto-thermal Plug flow reactors and Packed tubular reactors. PFR with inter-stage cooling. Shift of Energy and material balance lines for reversible reactions in CSTR, Examples of optimal design of PFR and Semi-batch and CSTR

Unit 4: Exothermic Reactions, Catalytic reactions: theory and modeling: Global rate of reaction, Types of Heterogeneous reactions Catalysis, Different steps in catalytic reactions, Theories of heterogeneous catalysis. Steady State approximation, formulations of rate law Rate laws derived from the PSSH, Rate controlling steps, Eiley-Rideal model, Reforming catalyst example :Finding mechanism consistent with experimental observations Evaluation of rate law parameters, packed beds : Transport and Reactions, Gradients in the reactors : temperature.

Unit 5: Porous media reactors: Mass transfer coefficients, Flow effects on spheres tube and cylinders, External Mass Transfer pore diffusion, structure and concentration gradients Internal Effectiveness Factor Catalytic wall reactor: limiting steps reactions and mass transfer limiting Porous catalyst on tube wall reactors Design of packed bed porous catalytic reactors: Mass transfer limited reactions in Packed bed Fluidized bed reactor modeling: Geldart Classification of powders, Fixed bed sersus fluidized bed Why fluidized bed, important parameters pressure drop in fixed bed, Class I model Arbitrary Two Region Flow Models, Class II Chemical Reactor: Plug Flow or Mixed Flow Model. Class III Modeling the Bubbling Fluidized Bed Reactor, BFB, The Kunii-Levenspiel bubbling bed model, Gas Flow Around and Within a Rising Gas Bubble in a Fine particle BFB, Reactor performance of BFB. Unit 6: Application of Population Balance Equations for reactor modeling: Particle size distribution, Distribution Functions in Particle Measuring Techniques, Particle distribution model in colloidal particle synthesis in batch reactor, Moments of Distribution, Nucleation rate based on volumetric holdup versus crystal growth rate. Reaction engineering and mitigation of Global warming: CO2 absorption in high pressure water, different techniques of mitigation of CO2, methods of separations. Recent advancements, automotive monolith catalytic converter example, removal and utilization of CO2 for thermal power plants.

Textbooks / References:

1. Foggler,H.S., Elements of Chemical Reaction Engineering, Prentice Hall of India, 2008.

2. Levenspiel O., Chemical Reaction Engineering, Wiley, 1998.

3. Fromment G.F. and Bischoff K.B., Chemical Reactor Analysis and Design, John Wiley, 2010.

THERMODYNAMICS OF PHASE EQUILIBRIA

Course Outcomes: At the end of the course, the student will be able to:

CO1	Understand the thermodynamics of equilibrium
CO2	Study properties from volumetric data and make use of empirical equations to predict fugacity of pure liquid or solid
CO3	Applications of thermodynamics to predict fugacity of liquid mixtures
CO4	Study the intermolecular forces and theories of corresponding states

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	√	-	-	-	-	-	-	-
CO2	√	√	-	-	-	-	-	-
CO3	√	√	-	-	-	-	-	-
CO4	√	√	-	-	-	-	-	-

Detailed Syllabus:

Unit 1: Introduction to molecular thermodynamics of fluid phase equilibrium, Fundamental concepts of statistical thermodynamics

Unit 2: Classical thermodynamics of phase equilibrium - open and closed systems, Gibbs-Duhem equation, chemical potential, fugacity and activity. Thermodynamic properties from volumetric data / fugacity at moderate pressure, fugacity of a pure liquid or solid

Unit 3: Fugacity in gas mixtures - Virial equation of state, fugacity from Virial equation, third Virial coefficient, chemical interpretations of deviation from gas phase ideality, fugacity at high pressure, Redlich - Kwong equation of state, solubility of solids and liquids in compressed gases

Unit 4: Fugacity in liquid mixtures: excess functions, activity and activity coefficient, testing of equilibrium data, Wohl's expansion for excess Gibbs energy, equations of van der Waal, Wilson and Renon equations for activity coefficient. Thermodynamic criteria of miscibility

Unit 5: Intermolecular Forces and the theory of corresponding states - potential energy functions for different molecular systems; Polar and non-polar molecules, Liquid phase models: van Laar, Scatchard-Hildebrand theory, Lattice theory, two liquid theories, Flory - Huggins theory.

Text/Reference Books:

1. Chemical Engineering Thermodynamics, Smith and Van Ness

2. Chemical Engineering Thermodynamics, T.E. Daubert

3. Chemical Engineering Thermodynamics, R.E. Balzhiser

4. Chemical Engineering Thermodynamics, S.I. Sandler

5. Molecular Thermodynamics of Fluid Phase Equilibria, J.M. Prausnitz

6. Properties of Gases and Liquids, R.C. Reid and T.K. Sherwood

PROGRAM ELECTIVE-I

A. ADVANCED HEAT TRANSFER

Course Outcomes: At the end of the course, the student will be able to:

CO1	Derive the governing differential equation for conduction and convection heat transfer
CO2	Solve the differential equation to obtain temperature profile in solid or fluid
CO3	Apply finite difference methods to solve problems in heat transfer
CO4	Calculate the net radiation loss from a surface in an enclosure of many surfaces

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	√	-	√	-	-	-	-	-
CO2	√	-	√	-	-	-	-	-
CO3	√	-	-	-	-	-	-	-
CO4	√	-	-	-	-	-	-	-

Detailed Syllabus:

Unit 1-2: Steady state heat conduction: General conduction equation, side conditions. One dimensional heat conduction without generation, Plane slab, Circular cylindrical shell, Spherical shell, Variable thermal conductivity, Conduction across composite barriers, Critical insulation thickness. Finite difference methods in steady state conduction.

Unit 3: Unsteady state condition: Exact analytical solutions and charts for infinite slab, cylinder and sphere, Semi-infinite slab, Lumped parameter method of transient analysis; Finite difference method; Transient finite difference solutions.

Unit 4: Natural Convection: Governing equations for velocity and temperature fields, partial differential equations, vertical plate solution, Forced Convection: The fundamental problem, analytical and semi-analytical solutions.

Unit 5: Radiation Heat transfer - Concepts, physical mechanism, properties, radiation shape factors, heat exchange between nonblack bodies, infinite parallel planes, Calculation of the net radiant loss; Net radiant loss from non-gray surfaces.

Text / References:

1. Sucec J, Heat Transfer, Jaico Publishing House, 2006.

2. Holman, J.P. and White P.R.S., Heat Transfer, 7th Ed., McGraw Hill, 2009.

B. CONCEPTUAL DESIGN OF CHEMICAL PROCESSES

Course Outcomes: At the end of the course, the student will be able to:

CO1	Implement the hierarchical approach to conceptual design
CO2	Optimize the input/output and recycle structure of the flow sheet
CO3	Design the best flow sheet using conceptual design
CO4	Synthesize heat exchanger network and separation systems

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	√	-	-	-	-	-	-	-
CO2	-	√	√	-	-	-	-	-
CO3	-	√	√	√	-	-	-	-
CO4	-	√	-	-	-	-	-	-

Detailed Syllabus:

Unit 1: The nature of process synthesis and analysis: Creative Aspects of process design, A Hierarchical approach to conceptual design. Engineering economics: Cost information required, estimating capital and operating costs, total capital investment and total product costs, time value of money, Measures of process profitability, Simplifying the economic analysis for conceptual designs.

Unit 2: Economic decision making: Design of a solvent recovery system, Problem definition and general considerations, Design of a gas absorber, Equipment design considerations, rules of thumb. Developing a conceptual design and finding the best flow sheet: Input information, batch versus continuous.

Unit 3: Input-output structure of the flow sheet: Decisions for the input-output structure, Design variables, Overall material balances, and stream costs, Process Alternatives. Recycle structure of the flow sheet: Decisions that determine the recycle structure, recycle material balances reactor heat effects, equilibrium limitations, compressor design and costs reactor design, recycle economic evaluation.

Unit 4: Separation system: General structure of the separation system, Vapor recovery system, Liquid separation system, Azeotropic systems, Rigorous material balances.

Unit 5: Heat-exchanger networks: Minimum heating and cooling requirements, Minimum number of exchangers, Area estimates, Design of minimum-energy heat exchanger networks, Loops and paths, Reducing the number of exchangers, Stream splitting, Heat and Power integration, Heat and distillation, Cost diagrams and quick screening of process alternatives: Cost diagrams, cost diagrams for complex processes, quick screening of process alternatives, HDA Process.

Text / References:

1. Douglas J. M., Conceptual Design of Chemical Processes, McGraw Hill, 1988.

2. Dimian A. C., Bidea C. S., Chemical Process Design, Wiley-VCH, 2008.

C. PROJECT EVALUATION

Course Outcomes: At the end of the course, the student will be able to:

CO1	Analyze alternative processes and equipment for manufacturing product
CO2	Perform economic analysis related to process and equipment design
CO3	Estimate the cost of manufacture
CO4	Evaluate project profitability

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1		√	√	√	-	-	-	-
CO2	-	-	√	-	-	-	-	-
CO3	-	-	√	-	-	-	-	-
CO4	-	-	√	√	-	-	-	-

Detailed Syllabus:

Unit 1: Introduction to Industrial Project Management: Nature of the Industrial Project, The Industrial Project Manager, The Professional Chemical Engineer, The Economic Basis of the Industrial Project. The

Mathematics of Finance: The Measurement of Interest, The Present Worth of Cash Flows, Annuities.

Unit 2: Project Evaluation Systematics: Principles of Preliminary Project Evaluation, Marketing Research, Demand Projection, Price Projection, Flow Sheet Development Methods in Cost Estimation. Equipment Design And Costing: Equipment Selection and Sizing for Preliminary Cost Estimates, Estimation of Purchased Cost of Equipment, Effect of Inflation upon Capital Costs, Cost of Equipment Installation, Reliability of Equipment Cost Estimation.

Unit 3: The Direct Fixed Capital Investment: The Estimation of Direct Fixed Capital, The Separate Estimation of Auxiliary Facilities, The Estimation of Piping Systems, Reliability of Capital Estimates. Depreciation: The Economic Impact of Depreciation, Methods of Determining Depreciation Charges.

Unit 4: Cost of Manufacture: The Elements of the Cost of Manufacture, Raw Materials and Utilities, Operating Labor, Regulated and Fixed Charges, The Total Cost for Sale, The Responsibility for Environmental Projection.

Unit 5: The Criterion for Economic Performance: The Capital for Transfer, Return on Investment, Profitability under Variable Conditions, Profitability Criteria Related to ROI, The Costs of Product Transportation. Cash Flow Analysis: Cash Flow Concepts, Net Present Worth, Discounted Cash Flow, Relative Merit of Profitability Criteria, The Analysis of Risk. The Analysis of Alternatives: The Analysis of Equipment Alternatives, The Analysis of Process and Investment Alternatives, Economic Optimization, Replacement Analysis, Plant Modification Decisions, Engineering Management of Construction Projects, Corporate Performance Analysis, Optimum Design and Design Strategy, Statistical Analysis in Design.

Text / References:

1. Valle-Riestra J. F., Project Evaluation in the chemical process Industries. McGraw Hill Book Co., 1983.

2. Peters M.S., Timmerhaus K. D. and West R. E., Plant Design and Economics for Chemical Engineers, Tata McGraw Hill., 5th Edition, 2011.

PROGRAM ELECTIVE-II

A. BIOPROCESS ENGINEERING

Course Outcomes: At the end of the course, the student will be able to:

CO1	Understand enzyme kinetics and cell kinetics
CO2	List the immobilization techniques
CO3	Calculate the time required for given conversion of a enzymatic reactions using the kinetic data
CO4	Select downstream processing method for purification of the product

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	√	-	-	√	-	-	-	-
CO2	√	√	-	-	-	-	-	-
CO3	√	√	-	√	-	-	-	-
CO4	√	√	√	-	-	-	-	-

Detailed Syllabus:

Unit 1: Introduction: Biotechnology, Biochemical Engineering, Biological Process, Definition of Fermentation.

Unit 2: Enzyme & Cell Kinetics: Introduction, Simple Enzyme Kinetics, Enzyme Reactor with Simple Kinetics, Inhibition of Enzyme Reactions, Other influences on Enzyme Reactions, Experiment: Enzyme Kinetics, Growth Cycle for Batch Cultivation.

Unit 3: Transport Phenomena in Bioprocess Systems, Bioreactor Design and Analysis.

Unit 4: Instrumentation and Control: Introduction, Instrumentation for Measurements of Active Fermentation, Sterilization.

Unit 5: Product Recovery Operations: Strategies to Recover and Purify Products, Separation of Insoluble. Products, Cell Disruption, Separation of Soluble Products, Finishing Steps for Purification, Integration of Reaction and Separation.

Text / References:

1. Veith W. R., Bioprocess Engineering, John Wiley & Sons, 1994.

2. Blanch H. W. and Clark D. S., Biochemical Engineering, Marcell and Dekker Inc., 1997.

3. Shuler M. L., Kargi F., Bioprocess Engineering: Basic Concepts,2nd Ed, Prentice Hall, 2001.

B. PROCESS INTENSIFICATION

Course Outcomes: At the end of the course, the student will be able to:

CO1	Apply process intensification in industrial processes.
CO2	Implement methodologies for process intensification
CO3	Understand scale up issues in the chemical process
CO4	Gain the scientific background, techniques and applications of intensification in the process industries
CO5	Identify and solve process challenges using intensification technologies

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	√	-	-	-	-	-	-	-
CO2	-	√	√	-	-	-	-	-
CO3	√	√	-	-	-	-	-	-
CO4	√	√	√	-	-	-	-	-
CO5	√	√	√	√	-	-	-	-

Detailed Syllabus:

Unit 1: Introduction: Techniques of Process Intensification (PI) Applications, The philosophy and opportunities of Process Intensification, Main benefits from process intensification, ProcessIntensifying Equipment, Process intensification toolbox, Techniques for PI application.

Unit 2: Process Intensification through micro reaction technology: Effect of miniaturization on unit operations and reactions, Implementation of Microreaction Technology, From basic Properties To 23 Technical Design Rules, Inherent Process Restrictions in Miniaturized Devices and Their Potential Solutions, Microfabrication of Reaction and unit operation Devices - Wet and Dry Etching Processes.

Unit 3: Scales of mixing, Flow patterns in reactors, Mixing in stirred tanks: Scale up of mixing, Heat transfer. Mixing in intensified equipment, Chemical Processing in High-Gravity Fields Atomizer Ultrasound Atomization, Nebulizers, High intensity inline MIXERS reactors Static mixers, Ejectors, Tee

mixers, Impinging jets, Rotor stator mixers, Design Principles of static Mixers Applications of static mixers, Higee reactors.

Unit 4: Combined chemical reactor heat exchangers and reactor separators: Principles of operation; Applications, Reactive absorption, Reactive distillation, Applications of RD Processes, Fundamentals of Process Modelling, Reactive Extraction Case Studies: Absorption of NOx Coke Gas Purification.

Unit 5: Compact heat exchangers: Classification of compact heat exchangers, Plate heat exchangers, Spiral heat exchangers, Flow pattern, Heat transfer and pressure drop, Flat tube-and-fin heat exchangers, Microchannel heat exchangers, Phase-change heat transfer, Selection of heat exchanger technology, Feed/effluent heat exchangers, Integrated heat exchangers in separation processes, Design of compact heat exchanger - example. Enhanced fields: Energy based intensifications, Sono-chemistry, Basics of cavitation, Cavitation Reactors, Flow over a rotating surface, Hydrodynamic cavitation applications, Cavitation reactor design, Nusselt-flow model and mass transfer, The Rotating Electrolytic Cell, Microwaves, Electrostatic fields, Sonocrystallization, Reactive separations, Superctrical fluids.

Text / References:

1. Stankiewicz, A. and Moulijn, (Eds.), Reengineering the Chemical Process Plants, Process Intensification, Marcel Dekker, 2003.

2. Reay D., Ramshaw C., Harvey A., Process Intensification, Butterworth Heinemann, 2008.

C. SELECTED TOPICS IN HEAT TRANSFER

Course Outcomes: At the end of the course, the student will be able to:

CO1	Derive the governing differential equation for conduction and convection heat transfer
CO2	Solve the differential equation to obtain temperature profile in solid or fluid
CO3	Apply finite difference methods to solve problems in heat transfer
CO4	Calculate the net radiation loss from a surface in an enclosure of many surfaces

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	√	-	√	-	-	-	-	-
CO2	√	-	√	-	-	-	-	-
CO3	√	-	-	-	-	-	-	-
CO4	√	-	-	-	-	-	-	-

Detailed Syllabus:

Units 1-5: Theoretical background to laminar and turbulent flow, heat transfer and analogies between heat and momentum transfer to non-Newtonian fluids in circular tubes; Theoretical relationships for laminar and turbulent flow in tubes and stirred vessels; Heat transfer in particles – fluid systems; Mechanism of heat flow in fixed, fluid, fluidized and moving bed reactors; Heat transfer in dilute phase transport; Applications of basic heat transfer equations for the design of fixed, fluidized and moving beds, and for heat exchangers of non – Newtonian fluids.

Text / References:

1. J. G. Kundsen and D. L. Katz, Fluid Dynamic and Heat Transfer, McGraw Hill, (1958).

2. A. H. P. Skelland, Non Newtonian flow and Heat transfer in a Fluidized Bed, Gosener goizdt, Moscow (1963).

RESEARCH METHODOLOGY

Course Outcomes: At the end of the course, the student will be able to:

CO1	To develop a research orientation among the scholars and to acquaint them with fundamentals of research methods
CO2	To develop understanding of the basic framework of research process
CO3	To identify various sources of information for literature review and data collection
CO4	To understand the components of scholarly writing and evaluate its quality

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1		√	√	√	-	-	-	-
CO2	-	-	√	-	-	-	-	-
CO3	-	-	√	-	-	-	-	-
CO4	-	-	√	√	-	-	-	-

Detailed Syllabus:

Unit 1: Introduction to Research, Defining research, Meaning of research, Objectives of research, Motivation in research, Types of research

Unit 2: Problem Formulation and Literature Review, Formulating the research problem, Literature review, Development of working hypothesis

Unit 3: Research Design and Planning, Important concepts in research design, Research life cycle, Developing a research plan

Unit 4: Modeling, Simulation, and Data Collection, Overview of modeling and simulation, Classification of models, Development of models, Experimentation and simulation, Methods of data collection

Unit 5: Statistical Analysis and Research Reporting, Sampling methods, Statistical analysis, Hypothesis testing, Research ethics, Plagiarism, Writing research proposals and papers

References:

1. J.P. Holman, Experimental Methods for Engineers.

2. C.R. Kothari, Research Methodology, Methods & Techniques.

3. R. A. Fisher, Statistical Methods for Research Workers, Cosmo Publications, New Delhi ISBN:81-307-0128-6

COMPUTATIONAL LAB - 1

Course Outcomes: At the end of the course, the student will be able to:

CO1	Solve complex chemical engineering problems by applying suitable numerical methods
CO2	Estimate the thermodynamic properties from implicit equations using C language/MATLAB
CO3	Design the process equipment using C/C++ language /MATLAB
CO4	Analyze and formulate a mathematical problem and solve the resulting system of linear set of equations, ODE, PDE using C/C++ programming/MATLAB

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	√	√	√	-	-	-	-	-
CO2	√	√	√	-	-	-	-	-
CO3	√	√	√	-	-	-	-	-
CO4	-	√	√	-	-	-	-	-

Detailed Syllabus:

Computation and design experiments will be conducted with the help of in-house code and available software out of: ASPEN, MATLAB, C/C++ LANGUAGE, POLYMATH, MINITAB, DWSIM, MS-EXCEL, DESIGN EXPERT, etc. for chemical engineering processes such as flash calculations, distillation column, reaction rate kinetics, pipe simulator, heat exchanger, continuous stirred tank reactor, optimization of process parameters and many more chemical engineering applications.

References:

1. Santosh K. Gupta, Numerical Methods for Engineers, 2nd Edition, New Age International (P) Ltd., New Delhi.

2. Steven C. Chapra &Raymond P Canale, Numerical Methods for Engineers, 4th Edition, Tata McGraw Hill, New Delhi.

3. Bruce A. Finlayson, Lorenz T. Biegler, Ignacio E. Grossmann, Mathematics in Chemical Engineering , 2006 Wiley.

4. Gilbert Strang, Linear Algebra and its applications, Harcouth Brace Jovanovich, 1988.

5. Laboratory Manual

STRESS MANAGEMENT WITH YOGA (AUDIT COURSE)

Course Objectives:

1. Understand the physiological and psychological aspects of stress and its impact on overall well-being.

2. Learn and practice specific yoga postures, breathing exercises, and relaxation techniques to alleviate stress.

3. Explore the connection between mindfulness, meditation, and stress reduction, fostering mental clarity.

4. Discover holistic practices that promote better sleep, nutrition, and overall lifestyle habits for stress management.

5. Develop practical skills to manage stress in daily life, enhancing resilience and promoting emotional balance.

Course Outcomes:

CO 1. Recognize the signs and sources of stress, understanding its effects on mental and physical well-being.

CO 2. Master a variety of yoga techniques, including postures, breathing, and meditation, to effectively manage stress.

CO 3. Acquire relaxation strategies that promote calmness, reduce anxiety, and enhance overall mental clarity.

CO 4. Incorporate healthy habits inspired by yoga principles to foster better sleep, nutrition, and self-care

routines.

CO 5. Develop practical skills to navigate and cope with stress, enhancing emotional balance and promoting a more harmonious life.

Detailed Syllabus:

Unit-1: Introduction to Yoga for Stress Management, Stress according to Western perspective, Stress-Eastern Perspective, Developmental process: Western and Eastern Perspective, Stress Hazards and Yoga

Unit-2: Meeting the challenges of Stress, Introduction to Stress Physiology, Stress, Appetite and Dietary, management- Modern and Yogic perspective, Sleep and Stress: understanding the relationship for effective management of stress

Unit-3: Stress Assessment methods- a valuable tool toward stress management, Role of Yoga in prevention and management of stress related disorders – a summary of research evidence, Concept of stress and its management - perspectives from Patanjali Yoga Sutra

Unit-4: Concept of stress and its management - perspectives from Bhagavad Gita, Bio-Psycho-Socio-Spiritual model of stress management, Yoga practices for Stress Management; Breathing practices: Hands in and out breathing, Hands stretch breathing, Ankle stretch breathing, Dog Breathing, Rabbit breathing, Tiger breathing, Sashankasana breathing, Bhujangasana breathing, Ardha Shalabhasana breathing (alternate legs), Straight leg raising (alternate legs), Straight leg raising (both legs), Sethubandhasana lumbar stretch, Instant Relaxation Technique (IRT)

Unit-5: Loosening Practices: Shoulder Rotation, Side bending, standing twist, Hip rotation, Thigh strengthening, Chakki chalan, Bhunamasana Chalana, Alternative toe touching, Side leg raising, Pavana muktasana kriya: Wind releasing pose movements, Quick Relaxation Technique (QRT), Asana practices: Tadasana, Ardhakati Chakrasana, Ardha Chakrasana, Trikonasana, Vrikshasana, Vakarasana, Janu Sirshasana, Ushtrasana, Sashankasana, Ardhamatseyndrasana, Paschimottanasana, Poorvottanasana, Gomukhasana, Makarasana, Bhujangasana, Salambha Shalabahasana, Dhanurasana, Setubandhasana, Sarvangasana, Mastyasana; Deep Relaxation Technique (DRT) Soorya Namaskar; Pranayama: Kapalbhati kriya and Sectional Breathing, Nadishuddhi Pranayama, Bhramari, Sheetali, Sitkari and Ujjayi, Om Meditation Cyclic Meditation, Integrated Yoga Module

Textbooks / References:

1. H R Nagendra and R Nagarathna. Yoga for Promotion of Positive Health. Swami Vivekananda Yoga Prakashana. 2011.

2. Contrada, R., & Baum, A. (Eds.). The handbook of stress science: Biology, psychology, and health. Springer Publishing Company. 2010

3. Al'Absi, M. (Ed.). Stress and addiction: Biological and psychological mechanisms. Elsevier. 2011.

4. Van den Bergh, O. Principles, and practice of stress management. Guilford Publications. 2021.

5. Swami Muktibodhananda, Hatha Yoga Pradipika, Bihar Scool of Yoga, 1998

6. Swami Satyananda Saraswati, Four Chapters on Freedom, Bihar Scool of Yoga, 1975

7. Swami Tapasyananda, Srimad Bhagavat Gita, Sri Ramakrishna Math, 2012

SYLLABUS FOR SEMESTER-II

ADVANCED MASS TRANSFER OPERATIONS

Course Outcomes: At the end of the course, the student will be able to:

CO1	Understand the concept of separation factor and separating agent.
CO2	Determine the degrees of freedom using phase rule and description rule
CO3	Compare multi-stage operations
CO4	Design binary distillation column using McCabe Thiele and Ponchon-Savarit methods
CO5	Design multi-component distillation columns using short cut and rigorous calculation methods

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	√	√	-	-	-	-	-	-
CO2	-	√	-	-	-	-	-	-
CO3	√	√	-	-	-	-	-	-
CO4	√	√	-	-	-	-	-	-
CO5	√	√	-	-	-	-	-	-

Detailed Syllabus:

Unit-1: Characterization of Separation processes: Inherent Separation Factors: Equilibration Processes, Inherent Separation Factors: Rate-governed Processes. Simple equilibrium processes: Equilibrium Calculations, Checking Phase Conditions for a Mixture, Multistage separation processes: Increasing Product Purity, Reducing Consumption of Separating Agent, Co-current, Crosscurrent, and Countercurrent Flow.

Unit-2: Binary multistage separation: Binary Systems, Equilibrium Stages, McCabe-Thiele Diagram, The Design Problem, Multistage Batch Distillation, Choice of Column Pressure. Binary multistage separations-general graphical approach: Straight Operating Lines, Curved Operating Lines Processes without Discrete Stages, General Properties of the y - x Diagram.

Unit-3: Energy requirements of a separation process: Minimum Work of Separation, Net Work Consumption, Thermodynamic Efficiency, network of potentially reversible process, partially reversible process and irreversible processes.

Unit-4: Multi-component: Equilibrium and simple distillation – Multi-component Flash calculation and Differential distillation, quantitative relationships.

Unit-5: Ternary and multi-component system fractionation: preliminary calculations, feed condition, column pressure, design procedure, number of equilibrium stages, feed location, estimation of number of theoretical plates – shortcut methods and rigorous calculation methods.

Text / References:

1. King C. J., Separation Processes, Tata McGraw Hill Book Company, 2nd Ed., New Delhi, 1983.

2. Vanwinkle M, Distillation, McGraw Hill Chemical Engineering Series, New York, 1967.

3. Holland C. D., Multi-component Distillation, Prentice Hall of India Pvt. Ltd., 1981.

ADVANCED SEPARATION TECHNIQUES

Course Outcomes: At the end of the course, the student will be able to:

CO1	Classify the membranes.
CO2	Differentiate various membrane processes
CO3	Understand the methods of membrane preparation
CO4	Compare membrane process with other methods of separation
CO5	Evaluate the flux of solvent and solute through membrane

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	√	-	-	-	-	-	-	-
CO2	√	-	-	-	-	-	-	-
CO3	-	-	√	-	-	-	-	-
CO4	-	-	√	-	-	-	-	-
CO5	-	-	-	√	-	-	-	-

Detailed Syllabus:

Unit 1-2: Solute transport parameters for membrane performance prediction in RO/UF systems involving aqueous and non-aqueous solution. Physico – chemical. Polar, on-polar criteria governing RO separations – membrane transport mechanism.

Unit 3: Membrane fouling and compaction. TFC membrane development RO/UF/Ed process design and module analysis. RO/F/ED and DD in acid and enzyme recovery from scarified hydrolytes.

Unit 4: Membrane techniques in reclamation of water and chemicals along with pollution control from industrial effluents.

Unit 5: Cost benefits analysis in resources cycling and environmental quality improvement by MT. Industrial processing with membranes – membrane reactor concept in biotechnology concentration. Gas separation by RO.

Text / References:

1. S. Sourirajan and T. Matsuuura (Ed.), RO – UF: Principles and Applications, NRCC Publications, Ottawa, Canada (1986).

2. Munir Cheryan, UF Applications Handbook, Technique Publishing Co, Lancaster, USA (1986).

PROGRAM ELECTIVE - III

A. RISK ANALYSIS AND HAZOPS

Course Outcomes: At the end of the course, the student will be able to:

CO1	Identify the type of risk involved in a chemical plant operation
CO2	Manage risk and prepare disaster management options
CO3	Understand safety, energy and environmental impact audit
CO4	Implement the procedure of root cause/fault tree analysis
CO5	Conduct HAZOP study for ‘to be commissioned’ chemical plants

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	√	-	-	√	-	-	-	-
CO2	-	-	√	√	-	-	√	-
CO3	√	-	-	√	-	-	√	-
CO4	-	-	-	√	-	-	√	-
CO5	-	-	-	√	-	-	-	-

Detailed Syllabus:

Unit 1: Types of Risk analysis: What are Risks, threats and vulnerabilities? What are Risk assessment, Risk management and Risk communication? Basics and structure of Risk analysis. Qualitative and quantitative risk analysis. Types of failure: What is failure? Design failure, catastrophic failure, compounding failure and Human error failure.

Unit 2: Dispersion and toxic models: Parameters affecting dispersion, Neutrally buoyant dispersion models, Steady-State Continuous Point Release with No Wind, Puff with No Wind, Non-Steady-State Continuous Point Release with No Wind, Steady-State Continuous Point Source Release with Wind, Puff with No Wind and Eddy Diffusivity Is a Function of Direction, Steady-State Continuous Point Source Release with Wind and Eddy Diffusivity Is a Function of Direction, Puff with Wind, Puff with No Wind and with Source on Ground, Steady-State Plume with Source on Ground, Continuous Steady-State Source with Source at Height Hr above the Ground, Pasquill-Gifford Model, Puff with Instantaneous Point Source at Ground Level, Coordinates Fixed at Release Point, Constant Wind Only in x Direction with Constant Velocity u, Plume with Continuous Steady-State Source at Ground Level and Wind Moving in x Direction at Constant Velocity u, Plume with Continuous Steady-State Source at Height Hr above, Ground Level and Wind Moving in x Direction at Constant Velocity u, Puff with Instantaneous Point Source at Height Hr above Ground Level and a Coordinate System on the Ground That Moves with the Puff, Puff with Instantaneous Point Source at Height Hr above Ground Level and a Coordinate System Fixed on the Ground at the Release Point, Worst-Case Conditions, Limitations to Pasquill-Gifford Dispersion Modeling, Dense Gas Dispersion, Toxic Effect Criteria, Effect of release momentum and Buoyancy, Release Mitigation.

Unit 3: Fire and explosion models: The Fire Triangle, Distinction between Fires and Explosions, Flammability Characteristics of Liquids and Vapors, Liquids, Gases and Vapors, Vapor Mixtures, Flammability Limit, Dependence on Temperature, Flammability Limit Dependence on Pressure, Estimating Flammability Limits, Limiting Oxygen Concentration and Inerting, Flammability Diagram, Ignition Energy, Autoignition, Auto-Oxidation, Adiabatic Compression, Ignition Sources, Sprays and Mists, Explosions, Detonation and Deflagration, Confined Explosions, Blast Damage Resulting from Overpressure, TNT Equivalency, TNO Multi-Energy Method, Energy of Chemical Explosions, Energy of Mechanical Explosions, Missile Damage, Blast Damage to People, Vapor Cloud Explosions, BoilingLiquid Expanding-Vapor Explosions.

Unit 4: Risk Management and ISO14000: Disaster management plan: Scale of disaster, elements at risk, aims of disaster management, disaster management cycle, role players in disasters, disaster preparedness, disaster preparedness framework, disaster response activities. Emergency Planning: Internal Emergency Plan (for the employees of the company), Objectives of an internal emergency plan, The Preparation of an Emergency plan, Elements of an Emergency plan, Emergency Organization and Management. External Emergency Plan (for the surrounding communities). Case studies: Static Electricity, Tank Car Loading Explosion, Explosion in a Centrifuge, Duct System Explosion, Conductor in a Solids Storage Bin, Pigment and Filter, Pipefitter's Helper, Lessons Learned, Chemical Reactivity, Bottle of Isopropyl Ether, Nitrobenzene Sulfonic Acid Decomposition, Organic Oxidation, Lessons Learned, System Designs, Ethylene Oxide Explosion, Ethylene Explosion, Butadiene Explosion, Light Hydrocarbon Explosion,

Pump Vibration, Pump Failure, Ethylene Explosion, Ethylene Explosion, Ethylene Oxide Explosion,, Procedures, Leak Testing a Vessel, Man Working in Vessel, Vinyl Chloride Explosion, Dangerous Water Expansion, Phenol-Formaldehyde Runaway Reaction, Conditions and Secondary Reaction Cause Explosion. Fuel-Blending Tank Explosion. Hazard identification: Process Hazards Checklists, Hazards Surveys, Hazards and Operability Studies, Safety Reviews, Other Methods. Safety Audits: Types of audits (Internal &External), Audits objectives, Methodology in Conducting Safety audits (Pre-audit activities, Key on-sites activities and Post-audit activities). Checklists: Process hazard checklists.

Unit 5: What if Analysis: Examination of possible deviations from the design, construction, modification or operating intent of a process. Vulnerability models: Definitions of vulnerability, Characteristics of vulnerability, Types of vulnerability, Conceptual frame-works of vulnerability, Methods of Measuring physical vulnerability, Analytical Methods and Earthquake vulnerability curves. Event tree and Fault tree Analysis: Guidelines, examples, fault tree analysis symbols, building fault tree, DOs and DONOTs in fault tree analysis, Past accident analysis, Hazops, Principles, Risk ranking, Guide word, Parameter, Deviation, Causes, Consequences, Recommendation, Coarse HAZOP study, Case studies

Text / References:

1. Raghavan K. V. and Khan A. A., Methodologies in Hazard Identification and Risk Assessment, Manual by CLRI, 1990.

2. Marshal V. C., Major Chemical Hazards, Ellis Horwood Ltd., Chichester, United Kingdom, 1987.

3. Mannan S., Butterworth Heineman, Lees' Loss Prevention in the Process Industries, 4th Ed., Hazard Identification, Assessment and Control, 2012.

B. REACTIVE SEPARATIONS

Course Outcomes: At the end of the course, the student will be able to:

CO1	Understand the need for reactive separation process
CO2	Categorize reactive separation processes.
CO3	Understand the effect of thermodynamics and kinetics on the reactive separation process
CO4	Develop mass and energy balance equations for reactive separation processes

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	√	√	√	-	-	-	-	-
CO2	√	√	√	-	-	-	-	-
CO3	√	√	-	-	-	-	-	-
CO4	√	-	-	-	-	-	-	-

Detailed Syllabus:

Unit 1: Reactive Distillation: Definition, introduction to reactive distillation process. Thermodynamic and kinetic effects on the feasible products of RD: introduction, Azeotropes, azeotropes kinetics, azheotropes in reactive membrane separation, Equilibrium theory and nonlinear waves for reaction separation process. Reactive stripping in structured catalytic reactors: introduction, hydrodynamics, Reactive experiments, comparison of different internals.

Unit 2: Reactive Absorption: introduction, reactive absorption equipment, modeling concept, model parameters, case studies. Reactive Extraction: introductions, phase equilibria, reactive mass transfer, hydrodynamics.

Unit 3: Development of reactive crystallization process: introduction, work flow in process development, process synthesis, reactive phase diagrams, kinetic effects, asymmetric transformation of enantiomers.

Unit 4: Reactive extrusion for solvent free processing: introduction, advantages & disadvantages, main reactions in extruders, extruder types, kinetic considerations, heat transfer and thermal instabilities. Reactive comminution: introduction, mechanical comminution in solids, equipment and processes, applications.

Unit 5: Reactive filtration: introduction, separation of particulates and catalytic reaction of volatiles, separation of particles and reaction of solids. Reactive assisted granulation in fluidized beds: introduction, modeling, experiments.

Text / References:

1. Sundmacher K., Kienle A., Siedel A., Integrated Chemical Processes, Wiley VCH, 2005.

2. Kulprathipanja, Reactive Separation Processes, Taylor and Francis, 2002.

3. Luyben W. L. and Cheng-Ching Yu, Reactive Distillation Design and Control, John Wiley and Sons, 2008.

C. PINCH TECHNOLOGY

Course Outcomes: At the end of the course, the student will be able to:

CO1	Quantify the energy requirement for component equipment of a chemical plant
CO2	Develop the composite curves and locate the pinch point for heat exchanger network
CO3	Minimize energy requirement for the heat exchanger network
CO4	Implement pinch technique for batch and continuous processes
CO5	Optimize energy requirement for a large chemical plant by compartmentalizing appropriately

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	√	-	√	-	-	-	-	-
CO2	√	√	√	√	-	-	-	-
CO3	√	√	√	-	-	-	-	-
CO4	√	-	√	√	-	-	-	-
CO5	-	-	-	-	-	-	-	-

Detailed Syllabus:

Unit 1: Introduction: Pinch analysis, History, Concepts of process synthesis, Learning & applying techniques. Key concepts of Pinch analysis: Heat recovery & heat exchange, Significance, Heat Exchanger network design, Implications, Methodology.

Unit 2: Data extraction and energy targeting: Data extraction, Case study – organics distillation plant, Energy Targeting, Multiple utilities, Advance energy targeting, Targeting heat exchange units, area and shells, Super targeting – Cost targeting for optimal difference in temperature, case study – organic distillation plant.

Unit 3: HEN Design Utilities: Introduction, Heat Exchanger equipment, Stream splitting and cyclic matching, Network relaxation, complex design, multiple pinches and near pinches, retrofit design, operability, network design for organics distillation – case study. Heat and power systems: Introduction, CHP systems, Heat pump & refrigeration system, total site analysis, organic distillation unit, case studies.

Unit 4: Process change and evolution: Introduction, principles, reactor systems, distillation column,

separation systems, applications to the organic distillation. Batch and time dependent processes: Introduction, streams in batch processes, time intervals, calculating energy targets, heat exchanger network design, rescheduling, debottlenecking, time dependent applications.

Unit 5: Applying the Technology in Practice: Introduction, Pinch study, heat & mass balance, Stream data extraction, targeting & network design, Targeting softwares, industrial experience. Case Studies: Introduction, crude preheat train, aromatics plant, Evaporation plants, organic chemicals manufacturing site.

Text / References:

1. Kemp I. C., Pinch Analysis and Process Integration, 2nd Ed., 2007, Elsevier Publication.

2. Noureddin M. B., Pinch Technology and Beyond Pinch, New Vistas on Energy Efficiency Optimization, Booktopia 2011.

3. Biegler L. T., Grossmann I. E. and Westerberg A. W., Systematic Methods of Chemical Process Design, Prentice Hall International, 1997.

PROGRAM ELECTIVE - IV

A. COMPUTER CONTROL OF PROCESS PLANTS

Course Outcomes: At the end of the course, the student will be able to:

CO1	Apply cascade control, feed-forward control, ratio control, time delay compensated controller strategies to chemical processes.
CO2	Design controllers for multivariable loops.
CO3	Understand dynamic behavior of discrete time processes.
CO4	Design discrete controllers for first order and second order processes

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	-	√	-	-	-	-	-	-
CO2	-	√	-	-	-	-	-	-
CO3	√	-	-	-	-	-	-	-
CO4	-	√	-	-	-	-	-	-

Detailed Syllabus:

Unit 1: Advanced control strategies: Cascade Control, Feed-forward and ratio control, Time delay compensation, Inferential control; Nonlinear control, Adaptive control.

Unit 2: Control of multi input, multi output processes: Process interactions, Control loop interactions; Pairing of controlled and manipulated variables, Singular value analysis,

Unit 3: Tuning of multi-loop controllers, Decoupling, Supervisory control.

Unit 4: Digital computer control: Sampling and filtering of continuous measurements, Analog filters, digital filters, Z-Transforms, Development of discrete time models, Dynamic response of discrete time systems,

Unit 5: Analysis of sampled data control systems, Stability analysis. Design of digital controllers: Deadbeat, Dalhin and Vogel-Edgar Algorithms, Digital computer simulation of control systems.

Text / References:

1. Seborg D. E., Edgar T. F. and Mellichamp D. A., Process Dynamics and Control, John Wiley and Sons, 2010.

2. Coughnowr D. R. and LeBlanc S., Process Systems Analysis and Control, 3rd Edition, McGraw Hill International, 2011.

3. Stephanopolaus G., Chemical Process Control, Prentice Hall India, 2008.

B. STEADY STATE PROCESS SIMULATION

Course Outcomes: At the end of the course, the student will be able to:

CO1	Understand different approaches to simulation and define the problem for simulation.
CO2	Analyse the problem and identify degrees of freedom and understand the importance of property estimation methods.
CO3	Apply mathematical methods suitable for solving explicit iterative loops, sparse sets of equations, partitioning & precedence ordering and to find best tear stream sets.
CO4	Carry out steady state process simulation using sequential modular approach and equation oriented approach.

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	√	-	-	-	-	-	-	-
CO2	√	-	-	-	-	-	-	-
CO3	√	√	-	-	-	-	-	-
CO4	√	√	-	-	-	-	-	-

Detailed Syllabus:

Unit 1: Introduction: Steady-state flow sheeting and the design process, the total design project. Flow sheeting on the computer: Motivation for development, Developing a simulation model, Approaches to flow sheeting systems-examples. Solving linear and nonlinear algebraic equations: Solving one equation in one unknown, Solution methods for linear equations, General approaches to solving sets of nonlinear equations, Solving sets of sparse nonlinear equations.

Unit 2: Physical property service facilities: The data cycle, Computerized physical property systems, Physical property calculations. Degrees of freedom in a flow sheet: Degrees of freedom, Independent stream variables, Degrees of freedom for a stream and a unit, Degrees of freedom for a flow sheet.

Unit 3: The sequential modular approach to flow sheeting: The solution of an example flow sheeting problem, Other features: Handling design specifications, information streams and control blocks, Convergence of tear streams: Sequential convergence and simultaneous convergence, Partitioning and precedence ordering set of equations and a flow sheet, tearing a flow sheet, Finding the best tear set family.

Unit 4: Flow sheeting by equation solving methods based on tearing: A simple example, An example system based on equation solving, A complex example of selecting decision and tear variables for a flow sheet, Handling the iterated variables.

Unit 5: Simulation by linear methods: Introduction to linear simulation, Application to staged operations, Application to management problem. Simulation by Quasi-linear approach: Introduction to Quasi-linear methods, Simulation of flows in pipe networks, Application to distillation, Application to multiple reaction equilibrium, Towards process simulation by Quasi-linear methods.

Text / References:

1. Westerberg A. W., Hutchison H. P., Motard R. L. and Winter P., Process Flowsheeting, Cambridge University Press, 2011.

2. Benedek P. (Ed), Steady State Flowsheeting of Chemical Plants, Elsevier Scientific Publishing Co., 1980. 3. Babu B. V., Process Plant Simulation, Oxford University Press, 2004.

C. ENERGY MANAGEMENT

Course Outcomes: At the end of the course, the student will be able to:

CO1	Implement energy audit for a chemical plant
CO2	Suggest methods of conserving energy requirement
CO3	Evaluate the suitability of renewable energy resources
CO4	Analyze the energy utilization of a process equipment

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	-	-	√	-	-	-	-	-
CO2	-	-	√	-	-	-	-	-
CO3	-	-	√	-	-	-	-	-
CO4	-	-	√	-	-	-	-	-

Detailed Syllabus:

Unit 1: Energy Scenario: Energy use patterns, energy resources, Oil a critical resource, economic and environmental consideration, Future scenario

Unit 2: Heat & work: First & second law of thermodynamics, Heat Engines.

Unit 3: Energy Audit: Energy conversion, Energy index, Energy consumption representation - pie chart, Sankey diagram & load profile, general audit, detailed audit, waste heat recovery.

Unit 4: Targeting and Conservation: Energy utilization and conversion – thermal efficiency, Heat Exchangers – heat recovery, Air conditioners – supply and removal of heat.

Unit 5: Recent advances in energy: Solar energy, Wind energy, Nuclear energy, Biomass, Geothermal energy, Future Energy Alternatives. Case Studies: Energy conservation in alcohol industry, fertilizer industry, and pulp and paper industry, Energy conservation in different units of refinery like FCCU, HCU and ADU.

Text / References:

1. Murphy W.R. and Mckay G., Energy Management, Elsevier, 2007.

2. HinrichsR. A. and Kleinbach M. H., Energy: Its Use and the Environment, Cengage Learning, 2012

Online NPTEL courses for Program Elective-IV

Sr. No.	Name of Elective	NPTEL Course	Cr	Name of Instructor	Host Institute	Link
1.	Computer Control of Process Plants	Chemical Process Control	3	Prof. Sujit Jogwar	IIT Bombay	https://nptel.ac.in/courses/103101142
2.	Steady State Process Simulation	ASPEN Plus Simulation software – a basic course for beginners	3	Prof. Prabirkumar Saha	IIT Guwahati	https://nptel.ac.in/courses/103103209

COMPUTATIONAL LAB – 2

Course Outcomes: At the end of the course, the student will be able to:

CO1	Carry out thermodynamic property estimations using property estimation and property analysis in Aspen
CO2	Simulate and design individual Mixer, splitter, heat exchangers, pumps, compressors, flash units, reactors, distillation columns, calculator block, duplicator, multiplier models.
CO3	Simulate processes involving multiple units and apply sensitivity, design specifications and case study tools in Aspen.
CO4	Simulate and optimize process flow sheets including streams containing solids using sequential modular approach as well as equation oriented approach.
CO5	Carry out dynamic simulation, pinch analysis and cost estimation.
CO6	Design heat exchanger using Exchanger design and rating and distillation column using RADFRAC models.

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	√	√	-	-	-	-	-	-
CO2	√	√	-	-	-	-	-	-
CO3	-	√	-	-	-	-	-	-
CO4	-	√	-	-	-	-	-	-
CO5	-	√	√	-	-	-	-	-
CO6	√	√	-	-	-	-	-	-

Detailed Syllabus:

Solve the following steady state simulation exercises using available software/s.

· Physical property estimations.

· Simulation of individual units like, mixers, splitters, heat exchangers, flash columns and reactors

· Design and rating of heat exchangers

· Design and rating of distillation columns.

· Mass and Energy balances.

· Handling user specifications on output streams – Sensitivity and design Spec tools.

· Simulation of a flow-sheet and simulation exercises using calculator block

· Optimization Exercises

· Simulation using equation oriented approach

· Simulation of processes involving solids

· Costing and economic analysis using Aspen capital Cost estimation.

· Pinch analysis and design Heat exchanger networks using Aspen Energy Analyser.

· Dynamic Simulation.

Online NPTEL courses for Computational Lab-2:

Sr. No.	NPTEL Course	Cr	Name of Instructor	Host Institute	Link
1.	MATLAB based programming in chemical engineering	3	Prof. Parag A. Deshpande	IIT Kharagpur	https://nptel.ac.in/courses/103105220
2.	ASPEN Plus Simulation software – a basic course for beginners	3	Prof. Prabirkumar Saha	IIT Guwahati	https://nptel.ac.in/courses/103103209

MINI PROJECT

Course Outcomes: At the end of the course, the student will be able to:

CO1	Communicate with group of people on different research topics
CO2	Prepare a project report that includes consolidated information on a project topic

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	-	-	-	-	√	-	-	-
CO2	-	-	-	-	-	√	√	√

Detailed Syllabus:

Any topic of relevance to chemical and allied engineering and science.

PROJECT MANAGEMENT / INTELLECTUAL PROPERTY RIGHTS

COURSE OUTCOMES: At the end of the course the student will be able to:

1) Enumerate and demonstrate fundamental terms such as copy-rights, Patents, Trademarks etc.

2) Interpret and follow Laws of copy-rights, Patents, Trademarks and various IP registration Processes to register own project research.

3) Exhibit the enhance capability to do economic analysis of IP rights, technology and innovation related policy issues and firms' commercial strategies.

4) Develop awareness at all levels (research and innovation) of society to develop patentable technologies.

5) Apply trade mark law, copy right law, patent law and also carry out intellectual property audits.

6) Manage and safeguard the intellectual property and protect it against unauthorized use.

Detailed Syllabus:

A. Project Management:

Unit-1: Introduction to Project management: Characteristics of projects, Definition and objectives of Project Management, Stages of Project Management, Project Planning Process, Establishing Project organization. Work definition: Defining work content, Time Estimation Method, Project Cost Estimation

and budgeting, Project Risk Management, Project scheduling and Planning Tools: Work Breakdown structure, LRC, Gantt charts, CPM/PERT Networks.

Unit-2: Developing Project Plan (Baseline), Project cash flow analysis, Project scheduling with resource constraints: Resource Leveling and Resource Allocation. Time Cost Trade off: Crashing Heuristic.

Unit-3: Project Implementation: Project Monitoring and Control with PERT/Cost, Computers applications in Project Management, Contract Management, Project Procurement Management. Post-Project Analysis.

B. IPR:

Unit-4: Introduction to IPR; Overview & Importance; IPR in India and IPR abroad; Patents ;their definition; granting; infringement; searching & filing; Utility Models an introduction. Copyrights; their definition; granting; infringement; searching & filing, distinction between related and copy rights; Trademarks, role in commerce, importance, protection, registration; domain names.

Unit-5: Industrial Designs; Design Patents; scope; protection; filing infringement; difference between Designs & Patents' Geographical indications, international protection; Plant varieties; breeder's rights, protection; biotechnology& research and rights managements; licensing, commercialization; legal issues, enforcement; Case studies in IPR.

REFERENCES:

1) Shtub, Bard and Globerson, Project Management: Engineering, Technology, and Implementation, Prentice Hall, India.

2) Lock, Gower, Project Management Handbook.

3) Prabuddha Ganguli, IPR published by Tata McGraw Hill 2001.

IKS (BUCKET)

HISTORY OF SCIENCE AND TECHNOLOGY IN INDIA

Course Outcomes: At the end of the course, the student will be able to:

CO1	Appreciate Indian contribution to science and technology Appreciate the development of different branches of science in ancient India
CO2	Learn the development of Mathematics and Astronomy in India
CO3	Learn the development of Ayurveda in India
CO4	Understand development in Agriculture and Metallurgy.

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1								
CO2								
CO3								
CO4								

Detailed Syllabus:

Unit-1: Introduction: Logic and methodology of Indian sciences, An overview of Indian contributions to sciences, An overview of Indian contributions to technology.

Unit-2: Astronomy: Development of astronomy in India, Pancanga: Indian calendrical computations, The distinct features of Indian planetary models, Computation of eclipses: Its simplicity, elegance and efficiency, Observational astronomy in India.

Unit-3: Mathematics: An overview of the development of mathematics in India, Mathematics contained in Sulbasutras, Combinatorial aspects of the Chandassastra, Solutions to the first and second order indeterminate equations, Weaving mathematics into beautiful poetry: Bhaskaracarya, The evolution of sine function in India, The discovery of calculus by Kerala astronomers.

Unit-4: Ayurveda: History of Ayurveda, Rational foundations of Ayurveda, Textual sources in Ayurveda, Ayurveda and allied disciplines, Approach to health and disease in Ayurveda, Approach to diet and nutrition in Ayurveda, Ayurveda and modern medicine, Ayurveda and Yoga.

Unit-5: Technological development in India: Agriculture: Origin and development, Ancient crops,·Traditional practices, Water management: Overview, Harappan water management, Other case studies, Medieval Water structures, Pottery: Overview, Technical aspects, Silpasastra: Architecture and Construction, An introduction to Silpasastra, Construction Technology, Metallurgy, Copper/Bronze/Zinc, Iron and Steel Technology in India

REFERENCES:

1) Dr. Binod Bihari Satpathy, "History of Science and Technology in India".

INDIAN ART: MATERIALS, TECHNIQUES AND ARTISTIC PRACTICES

Course Objectives:

1. To introduce the diversity of art practices and material culture from the Indian subcontinent.
2. To situate these practices against their socio-cultural, political and temporal settings.
3. To support an immersive approach to understanding Indian art.
4. To bring together the recent findings in Indian art

Course Outcomes: At the end of the course, the student will be able to:

CO1	Draw connections between the historical artifacts and contemporary objects from the immediate surroundings
CO2	Encourage themselves as an art practitioner, aspiring art historians, educators, and those preparing for competitive examinations in India
CO3	Direct the possible ways of exploring these thematic

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1								
CO2								
CO3								
CO4								

Detailed Syllabus:

Unit-1: Clay and Architecture I: Clay: Terracotta and Terracruda, How is clay processed into objects?, Brick structures and urns from the Indus Valley and Megalithic sites in south India, Sculptures of terracotta and bronze from Harappa, Terracruda or unbaked clay-made objects and rituals.

Architecture I: Basics of Buddhist and Jain architecture- Wood, stone and living rock, Stupa, vihara, caves and temples from Shunga, Kushana, Maurya and Gupta periods.

Unit-2: Pigment and Architecture II: Pigment: Mineral and vegetal colours- How pigment-based paints are processed and applied to walls Bhimbetka drawings, Murals of Sittanavasal and Ajanta.
Architecture II: Hinduism and temple building- Architectural treatise and utilisation of Vastupurusha mandala for making temples, Temples of Badami Chalukyas, Rashtrakuta, Chola, Chandela and Eastern Ganga dynasties.
Unit-3: Stone and Garden Stone: Memorials, Architectural Remnants and Objects- Types of stone in India: Mathura Sandstone, Deccani Basalt, Rajasthani Marble, Stone carving for architecture, Hero stones and their social significance, Household items and objects in royal court.
Garden: Islam, the garden of paradise and afterlife, Tombs, palace, garden and waterways from the Mughal and Deccani context, Regional and foreign flora and fauna in Mughal and Deccani gardens.
Unit-4: Paper and Printing: How does paper affect the character of painting and calligraphy? How are ink and pigments prepared? Jain manuscripts and Islamic treatise, Mughal, Deccani, Rajput and Pahari miniature paintings, Mysore and Tanjore paintings.
Printing: European Interventions -Printmaking techniques and their application in books and images, Bazar paintings of Kalighat and Battala woodcuts, Lithograph and Oleograph from Calcutta, Pune and Lucknow.
Unit-5: Multimedia Approaches: Introduction to the key developments in Indian Art after 1947, Post-independence artistic and design practices, Canvas painting, textile, furniture making between the 1950s and 1990s, Neoliberalism, transnational connections and "new media" approaches, Curatorial and collaborative projects between artists, educators and communities, Biennale, entrepreneurship and expansive notion of "art" after 2010.

Text Books/References:

1. Ali, Daud and Emma Flatt eds. 2020. Garden and landscape practices in pre-colonial India: histories from the Deccan. New Delhi: Routledge.
2. Dehejia, Vidya. 2006. Chola: Sacred Bronzes of Southern India. London: Royal Academy of Arts.
3. Goswamy, B. N., and Eberhard Fischer. 2017. Pahari Paintnings: The Horst Metzger collection in the Museum Rietberg. New Delhi: Niyogi Books.
4. Hardy, Adam. 2007. The Temple Architecture of India. Chichester (GB): J. Wiley and Sons.
5. Huntington, Susan. 1993. The Art of Ancient India: Buddhist, Hindu, Jain. New York: Weatherhill.
6. Koch, Ebba. 2001. Mughal Art and Imperial Ideology: Collected Essays. New Delhi: Oxford University Press.
7. Meister, Michael and M. A. Dhaky. 1999. Encyclopedia of Indian Temple Architecture. New Delhi: Manohar Publishers.
8. Mitter, Partha. 2001. Indian Art. Oxford and New York: Oxford University Press.
9. Sengupta, Paula. 2012. The Printed Picture: Four Centuries of Indian Printmaking. New Delhi: Delhi Art Gallery.
10. Singh, Kavita, ed. 2018. Scent upon a Southern Breeze: the synaesthetic arts of the Deccan. Mumbai: Marg.
11. Subramanyan, K. G. 2007. The Magic of Making: Essays on Art and Culture. Calcutta: Seagull.

CONCEPTS AND APPLICATIONS IN ENGINEERING

Course Outcomes: At the end of the course, the student will be able to:

CO1	Learn various aspects related to vedas and ancient literature
CO2	Appreciate the development of Mathematics and Astronomy in India
CO3	Understand the development of Metallurgy in India
CO4	Appreciate the knowledge of architecture and language system in India

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1								
CO2								
CO3								
CO4								

Detailed Syllabus:

Unit-1: The Vedic Corpus: Introduction to Vedas, A synopsis of the four Vedas, Sub-classification of Vedas, Messages in Vedas, Introduction to Vedāṅgas, Prologue on Śikṣā and Vyākaraṇa, Basics of Nirukta and Chandas, Introduction to Kalpa and Jyotiṣa, Vedic Life: A Distinctive Features. Number systems in India - Historical evidence, Salient aspects of Indian Mathematics, Bhūta-Saṃkhyā system, Kaṭapayādi system, Measurements for time, distance, and weight. Piṅgala and the Binary system

Unit-2: Mathematics: Introduction to Indian Mathematics, Unique aspects of Indian Mathematics, Indian Mathematicians and their Contributions, Algebra, Geometry, Trigonometry, Binary mathematics and combinatorial problems in Chandaḥ Śāstra, Magic squares in India. Astronomy: Introduction to Indian astronomy, Indian contributions in astronomy, The celestial coordinate system, Elements of the Indian calendar, Notion of years and months. Pañcāṅga – The Indian calendar system. Astronomical Instruments (Yantras), Jantar Mantar of Rājā Jai Singh Sawai

Unit-3: Engineering and Technology: Metals and Metalworking: Wootz Steel: The rise and fall of a great Indian technology, The Indian S & T heritage, Mining and ore extraction, Metals and metalworking technology, Iron and steel in India, Lost wax casting of idols and artefacts, Apparatuses used for extraction of metallic components. Irrigation systems and practices in South India, Literary sources for science and technology, Physical structures in India, Irrigation and water management, Dyes and painting technology, The art of making perfumes, Surgical techniques, Shipbuilding, Sixty-four art forms (64 Kalās), Status of Indigenous S & T

Unit-4: Town Planning and Architecture: Perspective of Arthaśāstra on town planning, Vāstu-śāstra – The science of architecture, Eight limbs of Vāstu, Town planning, Temples in India: marvelous stone architecture for eternity, Temple architecture in India, Iconography. Knowledge Framework and classifications: Indian scheme of knowledge, The knowledge triangle, Prameya – A vaiśeṣikan approach to physical reality, Dravyas – the constituents of the physical reality, Attributes – the properties of substances and Action –the driver of conjunction and disjunction, Sāmānya, viśēṣa, samavāya,

Unit-5: Pramāṇa – the means of valid knowledge, Saṃśaya – ambiguities in existing knowledge, Framework for establishing valid knowledge, Deductive or inductive logic framework, Potential fallacies in the reasoning process, Siddhānta: established tenets in a field of study, Introduction to Linguistics, Aṣṭādhyāyī, Phonetics, Word generation, Computational aspects, Mnemonics, Recursive operations, Rule based operations, Sentence formation, Verbs and prefixes, Role of Sanskrit in natural language processing

REFERENCES:

1) Mahadevan, B., Bhat Vinayak Rajat, Nagendra Pavana R.N. (2022), "Introduction to Indian Knowledge System: Concepts and Applications", PHI Learning Private Ltd. Delhi.

HUMANITIES AND SOCIAL SCIENCES

Course Outcomes: At the end of the course, the student will be able to:

CO1	Learn various aspects related to vedas and ancient literature
CO2	Appreciate the development of language system and philosophy in India
CO3	Understand the development of Ayurveda and health wellness in India
CO4	Appreciate the knowledge of architecture and administration system in India

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1								
CO2								
CO3								
CO4								

Detailed Syllabus:

Unit-1: The Vedic Corpus: Introduction to Vedas, A synopsis of the four Vedas, Sub-classification of Vedas, Messages in Vedas, Introduction to Vedāṅgas, Prologue on Śikṣā and Vyākaraṇa, Basics of Nirukta and Chandas, Introduction to Kalpa and Jyotiṣa, Vedic Life: A Distinctive Features, Philosophical Systems: An introduction to philosophical systems, Development of philosophy, Unique features of philosophy, Sāṅkhya approach of philosophy, Introduction to Yoga, Tenet of Nyāya philosophy, Principles of Vaiśeṣika, Doctrine of Pūrva-Mīmāṃsā Darśana, Thesis of Vedānta and synopsis of Advaita, Philosophy of Viśiṣṭādvaita, Ideology of Dvaita, Tenets of Jaina, Doctrine of Buddhism, Notions of Cārvāka

Unit-2: Wisdom through the Ages: Gateways of ancestral wisdoms, Introduction to Purāṇa, The Purāṇic repository, Issues of interest in Purāṇas, Introduction to Itihāsas, Key messages in Itihāsas, Wisdom through Nīti-śāstras, Wisdom through Subhāṣita, Knowledge Framework and classifications: Indian scheme of knowledge, The knowledge triangle, Prameya – A vaiśeṣikan approach to physical reality, Dravyas – the constituents of the physical reality, Attributes – the properties of substances and Action – the driver of conjunction and disjunction, Sāmānya, viśēṣa, samavāya, Pramāṇa – the means of valid knowledge, Saṃśaya – ambiguities in existing knowledge, Framework for establishing valid knowledge, Deductive or inductive logic framework, Potential fallacies in the reasoning process, Siddhānta: established tenets in a field of study

Unit-3: Linguistics: Introduction to Linguistics, Aṣṭādhyāyī, Phonetics, Word generation, Computational aspects, Mnemonics, Recursive operations, Rule based operations, Sentence formation, Verbs and prefixes, Role of Sanskrit in natural language processing; Number Systems and Units of Measurement: Number systems in India – Historical evidence, Salient aspects of Indian Mathematics, Bhūta-Saṃkhyā system, Kaṭapayādi system, Measurements for time, distance, and weight, Piṅgala and the Binary system

Unit-4: Health Wellness and Psychology: Introduction to health, Āyurveda: approach to health, Sapta-dhātavaḥ: seven-tissues, Role of agni in health, Tri-doṣas, Āyurveda: definition of health, Psychological aspects of health, Disease management elements, Dinacaryā: daily regimen for health & wellness, Importance of sleep, Food intake methods and drugs, Approach to lead a healthy life, Indian approach to psychology, The tri guṇa system & holistic picture of the individual, The Nature of Consciousness, Consciousness studies and issues,

Unit-5: Town Planning and Architecture: Perspective of Arthaśāstra on town planning, Vāstu-śāstra – The science of architecture, Eight limbs of Vāstu, Town planning, Temples in India: marvelous stone architecture for eternity, Temple architecture in India, Iconography, Governance and Public Administration: Introduction to raja dharma, Arthaśāstra: a historical perspective, Elements of a kauṭilyan state, The king & the amātya, Janapada & durga, Treasury and the State Economy (Kośa), Danda, Mitra, The Administrative Setup, Relevance of Arthaśāstra, Public Administration in Epics.

REFERENCES:

1) Mahadevan, B., Bhat Vinayak Rajat, Nagendra Pavana R.N. (2022), "Introduction to Indian Knowledge System: Concepts and Applications", PHI Learning Private Ltd. Delhi.

Sr. No.	NPTEL Course	Cr	Name of Instructor	Host Institute	Link
1.	History of Science and Technology in India	4	Prof. Madhav Govind	UGC-HRDC, Jawaharlal Nehru University New Delhi	https://onlinecourses.swayam2.ac.in/arp19_ap87/preview
2.	Indian Art: Materials, Techniques and Artistic Practices	4	Prof. Rajarshi Sengupta	Indian Institute of Technology Kanpur	https://onlinecourses.nptel.ac.in/noc22_hs133/preview
3.	Indian Knowledge System (IKS): Concepts and Applications in Engineering	4	Prof. B. Mahadevan, Dr. Vinayak Rajat Bhat, Dr. R Venkata Raghavan	Indian Institute of Management Bangalore (IIMB), Chanakya University, Bangalore	https://onlinecourses.swayam2.ac.in/imb23_mg53/preview
4.	Indian Knowledge System (IKS): Humanities and Social Sciences	4	Prof. B. Mahadevan, Dr. Vinayak Rajat Bhat, Dr. R Venkata Raghavan	Indian Institute of Management Bangalore (IIMB), Chanakya University, Bangalore	https://onlinecourses.swayam2.ac.in/imb23_mg55/preview
5.	Ancient Indian Management	2	Dr. Alka Jain	Taxila Business School	https://onlinecourses.swayam2.ac.in/aic22_ge19/preview

DISASTER MANAGEMENT

Course Outcomes: At the end of the course, the student will be able to:

CO1	Identify types of disaster
CO2	Understand issues originating from disaster like migration and rehabilitation
CO3	Understand disaster management policies and strategies in India
CO4	Learn from various case studies

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1								
CO2								
CO3								
CO4								

Detailed Syllabus:

Unit-1: Disaster Management: Disaster and Disaster Management – Concepts, Issues Concerned with Disaster Management, Phases of Disaster Management, Bhopal Disaster: A Case Study; Types of Disasters: Natural Disaster, Man-made Disaster

Unit-2: Types of Disasters: Slow onset Disasters & Rapid onset Disasters, Simple and Complex Disasters, Tsunami: A Case Study, Cyclone Phallin 2013: A Case Study; Disaster and Disaster Management in India, National institute of Disaster Management, National Disaster Management Act 2005, The National Policy on Disaster Management, 2009

Unit-3: National Plan on Disaster Management 2016, Refugee Problems, Impact of Disaster on the lives of Refugees, Problems of Women and Children during disasters, Principles of Psychosocial Care, Issues and Recovery During Emergency, Relationship between Disasters, Development and Vulnerabilities, Relationship between Disasters, Development and Vulnerabilities

Unit-4: Equity Issues in Disasters, Issues of Rehabilitation and Resettlement among the Disaster Survivors, Stakeholders in Disaster Relief Management: Central Government, State Government. District Administration, Armed Forces, Para-Military Forces, Fire Services

Unit-5: Disaster Risk Reduction Strategies, Risk Reduction Preparedness Plans, Action Plans and Procedures, Early Warning Systems, Components of Disaster Relief, Factors contributing to Vulnerability, Disaster Risk Reduction - Master Planning for the Future, Capacity Building Rehabilitation measures and long term reconstruction, Understanding Kerala Disaster 2018

References:

1. Disaster Management in India by Ministry of Home Affairs, Government of India

SYLLABUS FOR SEMESTER - III

PROGRAM ELECTIVE – V

A. OPTIMIZATION METHODS FOR CHEMICAL PROCESSES

Course Outcomes: At the end of the course, the student will be able to:

CO1	
CO2	
CO3	
CO4	

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1								
CO2								
CO3								
CO4								

Detailed Syllabus:

Unit-1: Introduction to Optimization, Optimization Problem Formulation, Basic Concepts of Optimization: Continuity of functions, Unimodal and multimodal functions, Optimality; Optimality criteria for unconstrained multivariable functions, Equality

Unit-2: Unconstrained Single Variable Optimization: Methods and Applications; Unconstrained Multivariable Optimization: Direct Search Methods

Unit-3: Unconstrained Multivariable Optimization: Gradient Based Methods; Introduction to Linear Programming

Unit-4: Linear Programming: The Simplex Method; Constrained Nonlinear Programming

Unit-5: Applications of Optimization; Software Tools for Optimization

References:

- Optimization of Chemical Processes – T. F. Edgar, D. M. Himmelblau and L. S. Lasdon, 2nd Edition, McGraw Hill, 2001
- Engineering Optimization: Methods and Applications - A. Ravindran, K. M. Ragsdell, G. V. Reklaitis, 2nd Edition, Wiley India, 2006
- Engineering Optimization: Theory and Practice - S. S. Rao, 4thEdition, John Wiley & Sons, Inc, 2009
- MATLAB Documentation (https://www.mathworks.com).

B. MODERN ANALYTICAL TECHNIQUES & INSTRUMENTATION

Course Outcomes: At the end of the course, the student will be able to:

CO1	
CO2	
CO3	
CO4	

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1								
CO2								
CO3								
CO4								

Detailed Syllabus:

Unit-1: Microscopy- Dark-field, Phase contrast, Fluorescence, Confocal, Polarization microscopy; Electron microscopy: TEM & SEM

Unit-2: Radioisotope techniques- Basic concepts, GM and scintillation counter, autoradiography, RIA, Applications in biological science

Unit-3: Chromatographic methods - General principles, Ion exchange, Gel filtration, Affinity and Gas chromatography techniques

Unit-4: Electrophoresis- General principles, Horizontal & Vertical Gel electrophoresis, Isoelectric focusing, 2D, Pulse field and immuno, electrophoresis, Centrifugation techniques- Basic principles, Different types of centrifuges, Analytical and Preparative Ultracentrifugation methods

Unit-5: Spectroscopic Techniques - Electromagnetic radiations; UV-Visible, fluorescence, CD, NMR, X-ray, Atomic absorption and Flame emission spectroscopic techniques, Mass spectrometry, Polymerase hain Reaction, DNA sequencing, ELISA

References:

1. Wilson K. and Walker J. "Principles and Techniques of Biochemistry and Molecular Biology" 6th Ed. Cambridge University Press, 2005.
2. Willard, H. H., Merritt L. L. Dean J. A. and Settle F. A.,"Instrumental Methods of Analysis", 7th Ed., Wadsworth Publishing Co., 1986.
3. Van Holde, K E, Johnson, W. and Ho, P. S., "Principles of Physical Biochemistry", Prentice Hall, 1981.
4. Cantor, C. R. and Schimmel, W.H., "Biophysical Chemistry Part-II", Freeman & Co., 1981.
5. Campbell, I.D. and Dwek, R.A., "Biological Spectroscopy", Benjamin Curmmings Publication Co. Inc., 1984.
6. Glasel, J. and Deutscher, M. B., "Introduction to Biophysical Methods for Protein and Nucleic acid Research", Academic Press, 1995.
7. Physical chemistry by D. Friedfelder WH Freeman and co., 1982.

C. PETROLEUM TECHNOLOGY

Course Outcomes: At the end of the course, the student will be able to:

CO1	
CO2	
CO3	
CO4	

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1								
CO2								
CO3								
CO4								

Detailed Syllabus:

Unit 1: Overview of Petroleum: History, recovery and evaluation of crude petroleum, Primary processing of crude oil, Secondary processing of petroleum fractions
Unit-2: Properties and testing of crude petroleum and petroleum products
Unit-3: Introduction and properties of straight-run cuts from distillation units
Unit-4: Upgradation of straight-run cuts from atmospheric distillation units
Unit-5: Purification processes, Fundamental of thermochemistry

References:

1. Modern Petroleum Technology, Volume 1 UPSTREAM, Edited by Richard A. Dawe, 6th Edition, Published on behalf of the Institute of Petroleum, 2000 JOHN WILEY & SONS LTD
2. Modern Petroleum Technology, Volume 1 DOWNSTREAM, Edited by Alan G. Lucas, 6th Edition, Published on behalf of the Institute of Petroleum, 2000 JOHN WILEY & SONS LTD
3. Petroleum Refinery Engineering by W. L. Nelson, Fourth edition, McGRAW-HILL Book Company
4. Fuels and Combustion, Samir Sarkar, CRC press, Third edition

Online NPTEL courses for Program Elective – V:

Sr. No.	Name of Elective	NPTEL Course	Cr	Name of Instructor	Host Institute	Link
1	Optimization Methods for Chemical Processes	Optimization in Chemical Engineering	3	Prof. Debasis Sarkar	IIT Kharagpur	https://onlinecourses.nptel.ac.in/noc21_ch02/preview
2	Modern Analytical Techniques & Instrumentation	Analytical Technologies in Biotechnology	3	Dr. Ashwani K. Sharma	IIT Roorkee	https://archive.nptel.ac.in/courses/102/107/102107028/
3	Petroleum Technology	Petroleum Technology	3	Prof. Sonali Sengupta	IIT Kharagpur	https://nptel.ac.in/courses/103105221

OPEN ELECTIVE (Bucket)

Sr. No.	NPTEL Course	Cr	Name of Instructor	Host Institute	Link
1.	Student Psychology	3	Dr. S. Renukadevi	National Institute of Technical Teachers Training and Research, Chennai	https://onlinecourses.swayam2.ac.in/ntr19_ed23/preview
2.	Strategic Management – The Competitive Edge	2	Prof. R Srinivasan	IISc Bangalore	https://onlinecourses.nptel.ac.in/noc23_mg85/preview
3.	Business Environment	4	Dr. Chhavi Jain	IIS (Deemed to be University), Jaipur	https://onlinecourses.swayam2.ac.in/imb23_mg49/preview
4.	Hospitality Industry In Tourism	4	Prof. H. Rajashekar	University of Mysore, Manasagangothri	https://onlinecourses.swayam2.ac.in/cec19_mg30/preview

A. STUDENT PSYCHOLOGY

Course Outcomes: At the end of the course, the student will be able to:

CO1	
CO2	
CO3	
CO4	

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1								
CO2								
CO3								
CO4								

Detailed Syllabus:

Unit 1: Teaching Learning Process, Student Characteristics, Types and Problems
Unit-2: Psychological Tests and Inventories, Student Motivation
Unit-3: Physical and Cognitive Development, Emotional and Social Development
Unit-4: Neuro-Linguistic Programming
Unit-5: Counselling Skills and Summary

References:

1. Sharma, R.A. (2007). Training Technology. Meerut : Surya Publications.
2. Sharma, R.A. (2007). Psychology of Teaching-Learning Process. Meerut : Surya Publications
3. B. Mukhopadhyay (1997). Motivation in Educational Management. New Delhi : Sterling Publishers

B. STRATEGIC MANAGEMENT – THE COMPETITIVE EDGE

Course Outcomes: At the end of the course, the student will be able to:

CO1	
CO2	
CO3	
CO4	

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1								
CO2								
CO3								
CO4								

Detailed Syllabus:

Unit 1: Introduction to Strategic Management; Concept of Corporate Strategy; Strategic Management Process; Board of Directors - Role and Functions; Top Management - Role and Skills; Board Functioning - Indian Context

Unit-2: Environmental Scanning; Industry Analysis; Synthesis of External Factors; External Factors Analysis Summary (EFAS) Internal Scanning; Value Chain Analysis; Synthesis of Internal Factors; Internal Factors Analysis Summary (IFAS)

Unit-3: Strategy Formulation; Strategic Factors Analysis Summary (SFAS) Business Strategy; Corporate Strategy Functional Strategy Strategic Choice

Unit-4: Strategy Implementation Organization Structure; Corporate Culture; Diversification; Mergers and Acquisitions; Evaluation and Control; Strategic Information Systems

Unit-5: Other Strategic Issues; R&D, IT, KM, Technology; Strategic Risk and other issues

References:

4. R Srinivasan Strategic Management- The Indian Context, Prentice Hall Learning, Sixth Edition, 2020
5. R Srinivasan Case Studies in Marketing- The Indian Context, Prentice Hall Learning, Seventh Edition, 2018

C. BUSINESS ENVIRONMENT

Course Outcomes: At the end of the course, the student will be able to:

CO1	
CO2	
CO3	
CO4	

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1								
CO2								
CO3								

CO4								

Detailed Syllabus:

Unit 1: Business: Concept of Business, Scope and Characteristics of Business, Types of Business Organisations, Liberalisation, Privatisation and Globalisation; Business Environment: Levels of Business Environment- External- Macro, Micro, Internal. Competitive Structure of Industries, PESTLE, SWOT, Porter's Five Forces Model Environment Analysis, Changing dimensions of Business Environment, Socio Cultural Environment, Demographic Environment.

Unit-2: Culture: Nature and Impact of Culture on Business, Cultural Elements- Language, Religion, Family, Aesthetics, Education, etc. Economic Environment, Nature of Economy, Elements of Economic Environment, Economic Systems and Business Environment; Economic planning in India, Economic Policies and Conditions

Unit-3: Polito-Legal Environment; Political Environment: Political Environment and Economic System Types of Political Systems, Risks posed by Political Systems; Political Institutions- Legislature, Executive, Judiciary, Role of Government in business; Legal Environment: Major regulations pertaining to Business, Intellectual Property Rights. Financial Environment: Financial System and its components; Financial Institutions in India and their role, Foreign Investments, Foreign Direct Investments; Need for FDI in developing countries, Factors influencing FDI

Unit-4: Natural and Technological Environment; Natural resources and sustainability, Renewable and Non-renewable resources; Environmental issues related to Business Global Warming, Carbon credits, Industries and Pollution; Technology and Competitive Advantage, Innovation, Technological Leadership, sources of technological dynamics, impact of technology on globalization, Technology transfer, technology adaption, Digitalization of Business;

Unit-5: Corporate Social Responsibility: CSR concept, Need for social responsibility of business, Social Responsibility of Business towards different groups; Barriers to social responsibility, Business Ethics, Corporate Governance; Social Audit; Economic Integration: Levels of Economic Integration, Effects of Economic Integration, Major Regional Trading Blocs; WTO- Objective and Evolution of GATT, Uruguay Round, GATT vs WTO, Organisation of WTO, Functions of WTO, TRIPS, TRIMS, GATS, Dispute Settlement Mechanism, Dumping and anti-dumping measures

References:

1. Business and Sustainability, Michael Blowfield
2. Green to Gold: How Smart Companies Use Environmental Strategy to Innovate, Create Value, and Build Competitive Advantage, Daniel C. Esty, Andrew S. Winston
3. The Triple Bottom Line: How Today's Best-Run Companies Are Achieving Economic, Social and Environmental Success - and How You Can Too, by Andrew Savitz
4. The New Sustainability Advantage: Seven Business Case Benefits of a Triple Bottom Line, Bob Willard

D. HOSPITALITY INDUSTRY IN TOURISM

Course Outcomes: At the end of the course, the student will be able to:

CO1	
CO2	
CO3	
CO4	

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1								
CO2								
CO3								
CO4								

Detailed Syllabus:

Unit 1: Structure of Hospitality Industry, Customer care in Hospitality Industry; Departmentalization in Hotels, Classifications of Hotels & Hotel Rooms, Basis for Classification of Hotels, Distribution Channel in Hospitality; Role of Management Information System (MIS) in Hospitality Industry; Communication in Hotels; Basics of Food production

Unit-2: Food Commodities, Food Additives in Food Production, Indian Cuisine, International Cuisine; Food Purchasing Control; Receiving Control, Storing Control and issuing Control; Production Control, Sales Control

Unit-3: Beverage Cost Control; Introduction to the Hotel Food Service Industry; Attributes of the Food & Beverage Service Staff; Food & Beverage Service Department Equipment; Menu, Beverages - Alcoholic (Wines & Spirits), Beverages - Non Alcoholic (Tea & Coffee), Various Personnel in Hotels

Unit-4: Introduction to House Keeping, Role of House Keeping Department, Bed Making Procedure in Hotels Room Cleaning Procedure in Hotels; Cleaning Public Areas & Pest Control, Organization & Functions of front Office, Quality of Front office in Hotels, Reservation Procedure in Hotels

Unit-5: Guest Registration, Front Office Accounting System, front office functions, Hygiene & sanitation, Hygiene & sanitation in Food Sector; Food Borne Illnesses, Environmental Hygiene pertaining to hotel kitchen and service area, Food laws, regulations, quality and food standards

References:

1. Sampad Kumar Swain, Jitendra Mohan Mishra, “Tourism principles and practices”, 2012
2. Denney G. Rutherford, “Hotel Management and Operations”, 1994.

ENVIRONMENTAL STUDIES

Course Outcomes: At the end of the course, the student will be able to:

CO1	
CO2	
CO3	
CO4	

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1								
CO2								
CO3								
CO4								

Detailed Syllabus:

Unit-1: Sustainability Concepts – Innovations and Challenges, Environmental Measurements from Different Disciplines
Unit-2: Ecology, Population & Environmental Chemistry, Physical Process in Environment
Unit 3: Environmental Biological Concepts, Environmental Risk Assessments with Concepts of EIA and LCA
Unit 4: Water – Quantity and Quality, Basics of Wastewater Collection, Treatment & Resource Recovery, Basics of Solid Waste, Soil and Noise Pollution
Unit 5: Basics of Air Pollution Issues – Global and Local, Case Studies

REFERENCES:

1. Gilbert M Masters and Wendell P Ela, "Introduction to Environmental Engineering and Science", Publisher: Pearson Education India; 3rd edition, ISBN-10:9332549761, ISBN-13: 978-9332549760
2. Howard Peavy, Donald Rowe, and George Tchobanoglous, "Environmental Engineering", Publisher: McGraw Hill Education; ISBN-10: 9351340260, ISBN-13: 978-9351340263

SEMINAR

Course Outcomes: At the end of the course, the student will be able to:

CO1	Communicate with group of people on different research topics
CO2	Prepare a seminar report that includes consolidated information on a research topic

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	-	-	-	-	√	-	-	-
CO2	-	-	-	-	-	√	√	√

Detailed Syllabus:

Any topic of relevance to chemical and allied engineering and science.

PROJECT WORK (STAGE - I)

Course Outcomes: At the end of the course, the student will be able to:

CO1	Identify the problem based on literature survey
CO2	Formulate the problem
CO3	Identify the methods or techniques required for the solution
CO4	Develop the solution methodology

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1								
CO2								
CO3								
CO4								

Guidelines:

When undertaking an M.Tech. project in Chemical Engineering, the process involves various stages, from selecting a topic to completing the final thesis. Here are the typical guidelines that can help navigate the project:

- Project Topic Selection
  Relevance: Choose a project related to current trends and challenges in chemical engineering (e.g., renewable energy, water treatment, industrial waste management, sustainability, etc.).
  Interest: Pick a topic that interests you, as it will keep you motivated throughout the project.
  Feasibility: Ensure that the project is feasible in terms of time, resources, and facilities available in your institution or at an industrial partner.
  Literature Review: Start with a thorough literature review to identify gaps in current research and technologies.

- Research Proposal
  Objective: Clearly define the project's goal (e.g., designing a new process, optimizing an existing system, simulating processes).
  Scope: Specify the boundaries of your project (what will be studied and what will not).
  Methodology: Describe the methods, techniques, and tools you will use, such as experimental work, process simulation, or theoretical analysis.
  Expected Outcomes: Highlight the expected results and their potential applications.
  Timeline: Provide a detailed schedule for completing different stages of the project (e.g., literature review, data collection, analysis, report writing).

- Resources Required: List any special equipment, software, or materials you will need.

SYLLABUS FOR SEMESTER - IV

PROJECT WORK (STAGE - II)

Course Outcomes: At the end of the course, the student will be able to:

CO1	Implement the methods/techniques identified in dissertation part-A
CO2	Analyze and interpret the results obtained
CO3	Compare the results obtained with literature
CO4	Demonstrate the original contribution to knowledge

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1								
CO2								
CO3								
CO4								

Guidelines:

The extended guidelines are:

- Project Execution
  Literature Survey: Conduct a comprehensive literature survey to understand the existing work and identify gaps.

  Data Collection/Simulation: Depending on your project, collect experimental data or carry out simulations. For experimental projects, ensure the experimental setup is well-planned.

  Process Design/Optimization: If your project involves process design or optimization, ensure that you apply the appropriate principles of thermodynamics, kinetics, fluid mechanics, and mass/energy balance.

  Modeling & Simulation: If modeling or simulation is involved, tools such as Aspen Plus, MATLAB, HYSYS, COMSOL, or others can be used depending on the nature of the project.

  Analysis & Interpretation: Analyze the results critically, comparing them with theoretical predictions or industry standards.

- Documentation & Report Writing
  Structure of the Thesis:

  Title Page: Include your project title, name, department, institution, and year.

  Abstract: Provide a concise summary of the problem, methodology, findings, and implications.

  Introduction: Explain the background, objectives, scope, and significance of the project.

  Literature Review: Summarize previous work related to your topic.

  Methodology: Describe the techniques and processes used in your project.

  Results and Discussion: Present your findings and interpret them.

  Conclusion: Summarize the key results and suggest future research or applications.

  References: List all the papers, books, and other sources you referred to during the project.

  Appendices: Include any additional material, such as charts, raw data, or code used for simulations.

Figures and Tables: Make sure figures and tables are properly labeled and referenced in the text. They should be clear and relevant.

Language & Clarity: Write in clear, professional language. Avoid jargon and ensure that your explanations are understandable to someone familiar with chemical engineering concepts.

- Supervision and Feedback
  Advisor/Guide: Regularly meet with your project advisor to discuss progress, challenges, and feedback.

  Peer Review: Seek feedback from peers or other experts to get different perspectives on your work.

- Presentation
  Prepare a Presentation: Summarize the key aspects of your project for the final defense. Focus on objectives, methodology, results, and conclusions.

  Time Management: Practice your presentation to stay within the time limit and be ready for questions from the faculty or committee members.

- Ethical Considerations
  Integrity: Ensure your work is original, and properly cite all sources of information. Avoid plagiarism.

  Environmental and Social Impact: Consider the ethical and environmental impact of your project, especially if it involves industrial applications.

- Final Submission
  Formatting: Follow the formatting guidelines provided by your institution (e.g., font size, spacing, margin size).

  Submission Deadline: Make sure to submit the project within the stipulated deadline.

  Soft and Hard Copies: Submit both soft (digital) and hard copies of your report, depending on your institution's requirements.