VII Semester:

S.No.	Course Code	Course Title	Category	Type	Credit	L	T	P
1.								
2.	22CHW401	Minor Project	Project	Theory	3	0	0	6
	22CHO401	Training Seminar	PC	Theory	2	0	0	4
4.		Program Elective-I	PE	Theory	3	3	0	0
5.		Program Elective-II	PE	Theory	4	3	1	0
		Program Elective-III	PE	Theory	3	3	0	0
6.		Open Elective-I	OE	Theory	3	3	0	0
Total					**18**	**12**	**1**	**10**

Program Elective-I		**Program Elective-II**	
22CHT924	Nano-materials & Characterization	22CHT921	Advanced Process Control
22CHT925	Operation Research	22CHT922	CFD in Chemical Engineering
22CHT929	Solid & Hazard Waste Management	22CHT923	Mechanical Design of Process Equipment
	Program Elective-III		
22CHT926	Optimization of Chemical Processes		
22CHT927	Polymer Science and Technology		
22CHT928	Process Integration		

SEMESTER – VII
Program Elective – I

1. Subject Code: 22CHT924 Course Title: Nano-materials & Characterization

2. Contact Hours: L: 3 T: 0 P:0
3. Credits: 3 Semester: VII
4. Pre-requisite: Nil.
5. Objective: To study the concept of nanotechnology, and understand the fabrication, characterization, and applications of nano-materials
6. Course Outcomes: Upon completion of this course, the students will be able to:
   i. Understand the concept of nano-material synthesis.
   ii. Understand the various characterization techniques for the characterization of nano-materials.
7. Details of Course:

Unit No.	Contents	Contact Hours
1.	Introduction of the course with course handout; Definitions and Concepts: Nanoscience, Nanotechnology, Nanoparticles, Technology that enables science. Nano in nature, Current themes in nanoscale science and technology. Commercial applications of nanotechnology, Nano-based products, The social dimensions of nanotechnology. Introduction to physics of solid state, Size dependence of properties, Energy bands of insulators, conductor and semiconductor	4
2.	Non-traditional nano-fabrication: Top-down approach, Bottom-up approach, Classification of synthesis methods, Physical methods-Mechanical milling, Laser Ablation method. Physical vapour deposition-inert gas condensation, Evaporation (Thermal, e-beam), Sputtering, Plasma Arcing, chemical vapour deposition (RF-plasma enhanced CVD and Microwave plasma enhanced CVD).Liquid Phase synthesis, Co-precipitation, Chemical reduction method, Nucleation and growth, Role of capping/stabilizing agent and surfactant. Hydrothermal/solvothermal method, Crystal growth process, Factors affecting the growth, Apparatus, Synthesis and characterization of nanoparticles. Sol-Gel method, Mechanism of sol and gel formation, Synthesis of Xerogel and Aerogel. Si processing fabrication, Nanodevices, CMOS, MOSFET devices, Lithography techniques. Optical lithography, Electron lithography, X-ray lithography	7
3.	Crystalline and amorphous solid, Types of Crystalline solids, Lattice, Unit cell, Crystal system. Atomic arrangements in unit cells, crystal planes, X-ray diffract from crystal planes, Miller indices of crystal planes, Basics of diffraction. X-ray diffraction, Bragg's law, Diffraction pattern study, Application of XRD. Methods of measuring properties, Surface area analysis, BET method, Pore size study	5
4.	Quantum confinement, Quantum dots, Difference between bulk semiconductor, Thin film semiconductor, Quantum wire and quantum dots; Discrete energy levels. Fabrication of quantum dots, Patterned	7

	growth, Self-organized growth, Applications of quantum dots. Process of self-assembly , Semiconductor island, Monolayer formation. Carbon nanostructures, Nature of carbon bond, New carbon structures, Discovery of C_{60}. Structure of C_{60} and its crystal, Superconductivity of C_{60}, Fullerenes. Carbon nanotubes, Fabrication, Structure. Properties of carbon nanotubes, Electrical, vibrational and mechanical properties; Applications of carbon nanotubes.	
5.	Optical spectroscopy of nanostructures, Fundamentals of Raman Spectroscopy, Light scattering phenomenon, Types of scattering, Stokes Scattering, Anti-stokes Scattering, Raman vs. Rayleigh scattering, Mechanism of Raman and Rayleigh scattering, Raman vs. IR, Raman scattering spectrum and infrared absorption spectrum, Energy level diagrams, Polarizability, Dipole moment, Raman-active and Non-Raman-active Vibrations (III), Raman Depolarization Ratios, Raman ative and IR active, Study of Raman spectra, Infrared spectroscopy for nanostructures, FTIR, Asymmetric and non-asymmetric stretchings, Bending vibration mode, Library of FTIR spectra, Components of IR instruments, Data interpretation from IR spectrum	6
6.	Scanning probe microscopy, Fundamental of electron microscopy, Magnification and resolution, Light microscope, Wave-particle duality for electrons. Electron sources, source characteristics, source types, source characteristics, Physics of electron emission, operation of electron gun. Mechanism of electron-solid interaction, Transmission electron microscope, Components of TEM, TEM imaging, Sample preparation for TEM, Scanning electron microscopy, SEM vs TEM, Components of SEM. FE-SEM vs SEM, SEM imaging, Sample preparation, EDAX analysis, Interpretation of data from SEM and TEM images. Selected area electron diffraction, Indexing of diffraction pattern, Bravais-lattice and cell parameters, Revision of scanning probe microscopy	6

8. Books:

(A) Text Books

S. No.	Authors / Name of Book / Publisher	Year of Publication
1	C. P. Jr. Poole and F. J. Owens, Introduction to Nanotechnology, John Wiley.	2003
2	J. D. Plummer, M. D. Deal and P. B. Griffin, Silicon VLSI Technology, Prentice Hall.	2000
3	C. Kittel, Introduction to Solid State Physics-A Chapter about Nanotechnology, John Wiley.	2004

1. Subject Code: 22CHT925 **Course Title: Operation Research**

2. Contact Hours: L: 3 T: 0 P: 0
3. Credits: 3 Semester: VII
4. Pre-requisite: Nil.
5. Objective: The Objective of the paper is to introduce the basic concepts of Operational Research and linear programming to the students.
6. Course Outcomes: Upon completion of this course, the students will be able to:
   i. Be able to understand the characteristics of different types of decision-making environments and the appropriate decision making approaches and tools to be used in each type.
   ii. Be able to build and solve Transportation Models and Assignment Models.
   iii. Be able to design new simple models, like: CPM, to improve decision-making and develop critical thinking and objective analysis of decision problems.
7. Details of Course:

Unit No.	Contents	Contact Hours
1.	**Introduction & Linear Programming Problem:** Nature and meaning of operations research, general methods for solving operations research problems, main characteristics of operations research in decision making, Role of computers in operations research. Formulation of LP problem, graphical solution of LP problem, general formulation of LP problem, slack and surplus problem, standard form of LP problem, matrix form of LP problem, some important definitions, assumptions in LPP, limitations of LP, Applications of LP.	8
2.	**Simplex Method:** Definition and notations, computational procedure, artificial variable technique- two phase method, Big-M method, disadvantages of Big M method over two phase method, degeneracy problem, method to resolve degeneracy, special cases- alternative solution, unbounded solutions, non-existing solution, solution of simultaneous equations by simplex method, flow chart of simplex method. **Duality in Linear Programming:** Concept of duality, primal-dual problems, rules for converting any primal problem into its dual, duality theorems, primal and dual correspondence, duality and simplex method, shadow prices in LP, advantages of duality. **Dual Simplex Method:** Computational procedure of dual simplex method, advantages of dual simplex over simplex method, different between simplex and dual simplex methods.	12
3.	**Assignment Problem:** Introduction, mathematical formulation of assignment problem, fundamental theorems, Hungarian method, unbalanced assignment problem, variations of assignment problem-	6

	maximal assignment problem, restriction on assignment, traveling salesman problem- formulation and solution procedure.	
4.	**Transportation Models:** Introduction, mathematical formulation, feasible, basic feasible and optimum solutions, tubular representation, loops in table, IBFS to transportation problem, moving towards optimum solution, degeneracy in transportation problem, unbalanced transportation problem, time minimizing transportation problem, transshipment problem.	6
5.	**Network Scheduling by PERT/CPM:** Introduction, Networks and basic components, Rules of network construction, Time calculations in networks, Critical Path Method (CPM), PERT, PERT calculations, Negative float and negative slack, Advantages of network.	8

8. Books:

(A) Text Books

S. No.	Authors / Name of Book / Publisher	Year of Publication
1	Operations Research, P K Gupta and D S Hira, S. Chand and Company LTD. Publications, New Delhi.	2007
2	Operations Research, An Introduction, Seventh Edition, Hamdy A. Taha, PHI Private Limited.	2006

(B) Reference Books

S. No.	Authors / Name of Book / Publisher	Year of Publication
1	Operations Research, Theory and Applications, Sixth Edition, J K Sharma, Trinity Press, Laxmi Publications Pvt. Ltd.	2016
2	Taha, H.A., “Operations Research, an introduction", 8th th edition, Prentice Hall.	2011
3	Rao, S.S., “Engineering Optimization: Theory and Practice,” 4th ed., New Age International, New Delhi.	2000

1. Subject Code: 22CHT929 **Course Title: Solid and Hazard Waste Management**

2. Contact Hours: L: 3 T: 0 P: 0
3. Credits: 3 Semester: VII
4. Pre-requisite: Nil.
5. Objective: Understanding the problems of municipal, biomedical, hazardous, electronic, and industrial wastes.
6. Course Outcomes: Upon completion of this course, the students will be able to:
    i. Carry out sampling and characterization of solid waste; analysis of hazardous waste constituents including QA/QC issues.
    ii. Understand health and environmental issues related to solid waste management.
    iii. Apply steps in solid waste management-waste reduction at source, collection techniques, materials and resource recovery/recycling, transport, optimization of solid waste transport, treatment and disposal techniques.
    iv. Economics of the onsite vs. offsite waste management options.
7. Details of Course:

Unit No.	Contents	Contact Hours
1.	Introduction of solid wastes including municipal, hospital, industrial, battery, electronics, and agro solid waste; legal issues and requirements for solid waste management and health and environmental issues related to solid waste management. Sampling and characterization of solid waste. Analysis of hazardous constituents in solid waste including QA/QC issues.	7
2.	Health and environmental issues related to solid waste management, Waste reduction at source - municipal and industrial wastes, Material and resource recovery/recycling from solid wastes.	8
3.	Methods of waste collection, collection techniques, waste container compatibility, waste storage requirements, transportation of solid wastes. Processing of solid waste: segregation, particle size reduction, autoclaving, microwaving, incineration, non-incineration thermal techniques, composting, bio-remediation, use of refuse derived fuels, land fill. Leachate treatment.	15
4.	Economics of on-site vs. off-site waste treatment and disposal (individual vs. common disposal). Waste minimization and concept of industrial ecology and industrial symbiosis, Integrated waste management practices.	10

8. Books:

(B) Text Books

S. No.	Authors / Name of Book / Publisher	Year of Publication
1	Batstone R., Smith J.E. (Jr.) and Wilson D. The Safe Disposal of Hazardous Wastes-the Special Needs and Problems of Developing Countries, The World Bank Technical Paper No. 93, Vol. I, II and III, Washington, DC, The World Bank.	1989
2	Central Public Health and Environmental Engineering Organization (CPHEEO), Manual on Municipal Solid Waste Management, New Delhi, Controller of Publications.	2000
3	Freeman H.M. Standard Handbook of Hazardous Waste Treatment and Disposal, New York, McGraw-Hill.	1988

(C) Reference Books

S. No.	Authors / Name of Book / Publisher	Year of Publication
1	Tchobanoglous G., Theisen H. and Vigil S. Integrated Solid Waste Management: Engineering Principles and Management Issues, New York, McGraw-Hill.	1993
2	Vesilind P.A., Worrell W.A. and Reinhart D.R. Solid Waste Engineering, Australia, CL Engineering.	2001

SEMESTER – VII
Program Elective – II

1. Subject Code: 22CHT921 **Course Title: Advanced Process Control**

2. Contact Hours: L: 3 T: 1 P: 0
3. Credits: 4 Semester: VII
4. Pre-requisite: Nil.
5. Course Objective: Develop understanding about the advanced control methods such as multivariable control, digital control, artificial intelligence techniques used in process industries.
6. Course Outcomes: Upon completion of this course, the students will be able to:
   i. Understand the multivariable control and interaction among control loops
   ii. Understand and analyze the digital control systems
   iii. Understand the process identification techniques and model predictive control
   iv. Work in MATLAB and Simulink
7. Details of Course:

Unit No.	Contents	Contact Hours
1.	Review of conventional control systems. Ratio, selective and split range control, cascade control	8
2.	Design of feed-forward control systems; Adaptive and Inferential Control; multivariable control; Control loop interaction and design of decouplers;	8
3.	Discrete-time systems; Z-transforms; Stability analysis of discrete-time systems;	8
4.	Design of digital feedback controller; deadbeat and Dahlin's controllers; Ringing and placement of poles; Process Identification and Adaptive control.	8
5.	Model predictive control; Artificial neural network and Fuzzy logic control. LTI models in MATLAB and Simulink.	8

8. Books:

(A) Text Books

S.No.	Authors / Name of Book / Publisher	Year of Publication
1	Stephanopoulos, G., “Chemical Process Control”, PHI, New Delhi.	2015

(B) Reference Books

S.No.	Authors / Name of Book / Publisher	Year of Publication
1	Coughanowr, D. R., LeBlanc, S.E., “Process Systems Analysis and Control”, 3rdEd., McGraw Hill.	2009
2	Bequette, B.W., “Process Control - Modeling, Design and Simulation,” Pretice Hall	2003
3	Seborg, D.E., Edgar, T.F., Mellichamp, D.A., Doyle III, F.A., “Process Dynamics and Control,” 4thEd., Wiley.	2016
4	Astrom, K. J. and Wittenmark, B., “Computer Controlled Systems: Theory and Design”, 3rdEd., Prentice Hall.	2012

Subject Code: 22CHT922 **Course Title: CFD in Chemical Engineering**

1. Contact Hours: L: 3 T: 1 P: 0
2. Credits: 4 Semester: VII
3. Pre-requisite: Nil.
4. Course Objective: To provide brief introduction of Computational Fluid Dynamics along with chemical engineering application specifically, analysis of fluid mechanics and heat transfer related problems.
5. Course Outcomes:Upon completion of this course, the students will be able to:
   i. Solve PDE
   ii. Use Finite Difference and Finite Volume methods in CFD modelling
   iii. Generate and optimize the numerical mesh
   iv. Simulate simple CFD models and analyze its results
6. Details of Course:

Unit No.	Contents	Contact Hours
1.	**Introduction**: Illustration of the CFD approach, CFD as an engineering analysis tool, Review of governing equations, Modeling in engineering, Partial differential equations- Parabolic, Hyperbolic and Elliptic equation, CFD application in Chemical Engineering, CFD software packages and tools.	6
2.	**Principles of Solution of the Governing Equations:** Finite difference and Finite volume Methods, Convergence, Consistency, Error and Stability, Accuracy, Boundary conditions, CFD model formulation. **Mesh Generation**: Overview of mesh generation, Structured and Unstructured mesh, Guideline on mesh quality and design, Mesh refinement and adaptation.	12
3.	**Solution Algorithms**: Discretization schemes for pressure, momentum and energy equations - Explicit and implicit Schemes, First order upwind scheme, second order upwind scheme, pressure-velocity coupling algorithms, velocity-stream function approach, solution of Navier-Stokes equations. **CFD Solution Procedure:** Problem setup – creation of geometry, mesh generation, selection of physics and fluid properties, initialization, solution control and convergence monitoring, results reports and visualization.	12
4.	**Case Studies**: Benchmarking, validation, Simulation of CFD problems by use of general CFD software, Simulation of coupled heat, mass and momentum transfer problem.	10

7. Books:

(A) Text Books

S. No.	Authors / Name of Book / Publisher	Year of Publication
1	Niyogi, P. Chakrabarty, S.K. and Laha, M.K., "Introduction to computational fluid dynamics', Pearson education.	2006
2	Ranade, V.V., "Computational flow modeling for chemical reactor engineering", Academic Press.	2002
3	Muralidhar, K., and Sundararajan, T. "Computational Fluid Flow and Heat Transfer", Narosa Publishing. House	2003

(B) Reference Books

S. No.	Authors / Name of Book / Publisher	Year of Publication
1	P.S. Ghosdastidar, "Computer Simulation of Flow and Heat Transfer", Tata McGraw-Hill.	1998
2	Suhas V. Patankar. "Numerical Heat Transfer and Fluid Flow", Taylor and Francis.	2018
3	LI J., G. H. Yeoh, C Liu. "A Computational Fluid Dynamics", ELSEVER.	2008
4	Anderson J.D. "Computational Fluid Dynamics", Mc-Graw Hills.	1995
5	J H Ferziger and M Peric, "Computational Methods for Fluid Dynamics", Springer.	2002
6	ANSYS Manual.	

1. Subject Code: 22CHT923   Course Title: Mechanical Design of Process Equipment

2. Contact Hours: L:3 T:1 P:0
3. Credits: 4   Semester: VII
4. Pre-requisite: Nil.
5. Objective: To understand the mechanical design methods for various process equipment.
6. Course Outcomes: Upon completion of this course, the students will be able to:
   i. Determine the parameters of equipment design and important steps involved in design.
   ii. Students demonstrated ability to design various components of process equipment as heads, shell, flanges and fittings and supports and complete design of a chemical ·
   iii. Design pressure vessels
   iv. Students understood design of storage vessel, mechanical design of various process equipment such as heat exchanger, distillation column, piping, reactors, etc.
7. Details of Course:

Unit No.	Contents	Contact Hours
1.	**Design Preliminaries:** Introduction, General design procedure, Equipment classification, Design codes, Design considerations, Design pressure, Design temperature, Design stress, Factor of safety, Design wall thickness, Corrosion allowance, Weld joint efficiency factor, Design loadings, Stress concentration, Thermal stress and Criteria of failure.	6
2.	**Pressure Vessels:** Classification of pressure vessels; Design of cylindrical and spherical shells under internal and external pressure; Selection and design of closures; Optimum length to diameter ratio of pressure vessel using common types of closures; Design of jacketed portion of vessels; Selection and design of nozzles; Elementary idea of compensation for openings; Selection of gaskets; Selection and design of flanges; Pipe thickness calculation under internal and external pressure; Introduction to inspection and non-destructive testing; Complete design calculations and shop drawing for at least one pressure vessel using heads and flanges as per code specifications.	18
3.	**Tall Tower Design:** Design of shell, skirt, bearing plate and anchor bolts for tall tower used at high wind and seismic conditions. **Supports:** Design of lug support and saddle support including bearing plates and anchor bolts.	8
4.	**Storage Tanks:** Filling and breathing losses; Classification of storage tanks; Design of liquid and gas storage tanks. **Heat Exchange Equipment:** Mechanical design and drawing of heat exchangers. **Foundation and Supports:** Foundation and supports for equipment/vessels, tall towers.	8

8. Books:

(B) Text Books

S. No.	Authors / Name of Book / Publisher	Year of Publication
1	Bhattacharya, B. C., "Introduction to Chemical Equipment Design: Mechanical Aspects," CBS Pub., Delhi.	2017
2	Joshi, M. V. and Mahajani, V. V., "Process Equipment Design," 5th Ed., Macmillan, Delhi.	2016

(C) Reference Books

S. No.	Authors / Name of Book / Publisher	Year of Publication
1	Sinnott, R.K., "Coulson and Richardson's Chemical Engineering," Vol 1A, 7thEd., Butterworth Heinmann, New Delhi.	2017
2	Brownell, L. E. and Young, H. E., "Process Equipment Design," John Wiley.	2004
3	Dawande, S. D., "Process Design of Equipment," 6th Ed., Central Techno. Pub. Nagpur,	2012
4	IS: 2825-1969, "Code of Practice for Mechanical Design of Unfired Pressure Vessels".	
5	IS: 803-1962, "Code of Practice for Design, Fabrication and Erection of Mild Steel Cylindrical Welded Oil Storage Tanks".	
6	IS: 1239-1968, "Specification of Mild Steel Tubes".	
7	IS: 4503-1967, "Specifications for Shell and Tube Type Heat Exchanger".	
8	IS Code for Pipe Line.	
9	ASTM and ASME codes.	

SEMESTER – VII
Program Elective – III

1. **Subject Code: 22CHT926** **Course Title: Optimization of Chemical Processes**
2. Contact Hours: L:3 T:0 P:0
3. Credits: 3 Semester: VII
4. Pre-requisite: Nil.
5. Course Objective: To study and apply optimization techniques in the chemical process industry.
6. Course Outcomes: Upon completion of this course, the students will be able to:
   i. Formulate the objective functions for constrained and unconstrained optimization problems
   ii. Use different optimization strategies
   iii. Use of different optimization techniques for problem solving
   iv. Solve transportation problems
7. Course Details:

Unit No	Contents	Contact Hours
1.	Problem formulation for the optimization, Basic concept of optimization. **Unconstrained Single Variable Optimization:** Newton, Quasi-Newton methods, polynomial approximation methods.	8
2.	**Unconstrained Multivariable Optimization**: Direct search method, conjugate search method, steepest descent method, conjugate gradient method, Newton's method	8
3.	**Linear Programming:** Formulation of LP problem, graphical solution of LP problem, simplex method, duality in Linear Programming, two- phase method.	8
4.	**Non-linear Programming with Constraints:** Necessary and sufficiency conditions for a local extremum, Quadratic programming, Successive linear programming, successive quadratic programming, Penalty and Barrier method, Generalized reduced gradient (GRG) method. Genetic Algorithm, MILP.	8
5.	**Introduction to Transportation Problems**, Solving Various types of Transportation Problems, Assignment Problems, Project Management, Critical Path Analysis, PERT. Applications of optimization in Chemical Engineering.	8

8. **Books:**

(A) Text Books

S.No.	Authors / Name of Book / Publisher	Year of Publication
1	Edgar, T.F., Himmelblau, D. M., Lasdon, L. S., “Optimization of Chemical Process”, 2nd Ed., McGraw-Hill.	2001
2	Rao, S. S., “Optimization Techniques”, Wiley Eastern, New Delhi.	1985

(B) Reference Books

S.No.	Authors / Name of Book / Publisher	Year of Publication
1	Godfrey, C.O. and Babu, B.V., “New Optimization Techniques in Engineering”, Springer-Verlag, Germany.	2004
2	Beveridge, G. S. and Schechter, R. S., “Optimization Theory and Practice”, McGraw- Hill, New York.	1970
3	Reklaitis, G.V., Ravindran, A. and Ragsdell, K. M., “Engineering Optimization- Methods and Applications”, John Wiley, New York.	1983
4	Taha, S.M., "Operations Research, an introduction", 6th Ed., Prentice Hall.	1997

1. Subject Code: 22CHT927 **Course Title: Polymer Science and Technology**

2. Contact Hours: L: 3 T: 0 P: 0

3. Credits: 3 Semester: VII

4. Pre-requisite: Nil.

5. Objective: To understand various fundamental concepts of polymers and related phenomena.

6. Course Outcomes: Upon completion of this course, students will be able to:

   i. Understand the basic concept of monomer, polymer and repeating units and their properties
   ii. Understand the basic concepts of degree of polymerization
   iii. Understand in detail about the chemistry of polymers and the possible chemical modification
   iv. Understand the physical and chemical characterization of raw materials

7. Details of Course:

Unit No.	Contents	Contact Hours
1	**Chemistry of Polymerization Reactions:** Functionality, polymerization reactions, polycondensation, addition free radical and chain polymerization. Co-polymerization, block and graft polymerizations, stereospecific polymerization.	12
2	**Polymerization Kinetics:** Kinetics of radical, chain and ionic polymerization and co-polymerization systems.	10
3	**Molecular Weight Estimation:** Average molecular weight: number average and weight average. Theoretical distributions, methods for the estimation of molecular weight.	6
4	**Polymerization Processes:** Bulk, solution, emulsion and suspension polymerization. Thermoplastic composites, fiber reinforcement fillers, surface treatment reinforced thermoset composites – Resins, fibers, additives, fabrication methods.	6
5	**Rheology:** Simple Rheological response, simple linear viscoelastic models – Maxwell, Voigt, material response time, temperature dependence of viscosity, Rheological studies.	6

8. Books:

(A) Text Books

S. No.	Authors / Name of Book / Publisher	Year of Publication
1.	Billmayer, F.W., JR., "Textbook of Polymer Science", John Wiley and Sons.	1994
2.	Fried, J. R., "Polymer Science and Technology", PHI.	2005

(B) Reference Books

S. No.	Authors / Name of Book / Publisher	Year of Publication
1.	Schmidt, A. K. and Marlies, G. A., "High Polymers - Theory and Practice", McGraw Hill.	1948
2.	McKelvey, J. M., "Polymer Processing," John Wiley.	1962
3.	Rodringuez, "Principles of Polymer Systems", Tata McGraw Hill.	1970

1. Subject Code: 22CHT928 **Course Title: Process Integration**

2. Contact Hours: L: 3 T: 0 P: 0

3. Credits: 3 Semester: VII

4. Pre-requisite: Nil.

5. Course Objective: To understand the energy and mass targets in design of processes.

6. Course Outcomes: Upon completion of this course, the students will be able to:

i. Understand of the fundamentals of process integration.

ii. Perform pinch analysis.

iii. Analyze and design heat exchanger networks.

iv. Minimize the water consumption and waste generation.

7. Details of Course:

Unit No.	Contents	Contact Hours
1.	**Introduction:** Process integration, Role of thermodynamics in process design, Concept of pinch technology and its application.	6
2.	**Heat Exchanger Networks:** Heat exchanger networks analysis**,** Simple design for maximum energy recovery, Loop Breaking & Path Relaxation, Targeting of energy, area, number of units and cost, Trading off energy against capital.	16
3.	**Network Integration:** Super targeting, maximum energy recovery (MER), Network for multiple utilities and multiple pinches, Grand Composite curve (GCC).	8
4.	**Mass Integration:** Distillation sequences. **Heat and Power Integration:** Columns, Evaporators, Dryers, and reactors. **Case studies:** Waste and wastewater minimization, Flue gas emission targeting.	10

8. Books:

(B) Text Books

S. No.	Authors / Name of Book / Publisher	Year of Publication
1	Linnh off, D.W., User Guide on Process Integration for the Efficient Use of Energy, Institution of Chemical Engineers.	1994
2	Smith, R., Chemical Process Design and Integration, John Wiley &Sons.	2005

(C) Reference Books

S. No.	Authors / Name of Book / Publisher	Year of Publication
1	Shenoy, V. U., Heat Exchanger network synthesis, Gulf Publishing.	1995
2	Kumar, A., Chemical Process Synthesis and Engineering Design, Vol. Tata McGraw Hill.	1982