IPS Academy
Institute of Engineering & Science
(*A UGC Autonomous Institute, Affiliated to RGPV, Bhopal*)
Scheme & Syllabus Based on AICTE Flexible Curricula
B. Tech, Chemical Engineering Department

Semester VII (Final Year)

S. No.	Course Type	Course Code	Course Title	Hrs./ Week			Credits
				L	T	P	
1	PCC	CH15	Process Equipment Design-II	3	1	-	3
2	PEC	CH 03	Professional Elective-III	3	1	-	3
3	PEC	CH 04	Professional Elective-IV	3	1	-	3
4	IOC	-	Inter-disciplinary Open Courses -I	3	1	-	3
5	LC	CH 15(P)	Process Equipment Design-II	-	-	2	1
6	PROJ	CH03	Project-Phase-I	-	-	10	5
7	PROJ	CH 04	Evaluation Of Internship	-	-	-	3
8	PROJ	CH 05	Seminar-II	-	-	4	2
Evaluation of Internship- *Completed in Fifth/Sixth Semester*							
						Total Credits	23

- **Professional Elective Courses-III**
  (A) Fluidization Engineering
  (B) Plant Utility
  (C) Chemical Project Engineering & Economics

- **Professional Elective Courses-IV**
  (A) Advance Separation Process
  (B) Catalysis
  (C) Polymer Technology

- **Interdisciplinary Open Courses-I**
  (A) Chemical Process Safety (offered by FT dept)
  (B) Artificial Intelligence and Machine Learning (offered by CSE dept)
  (C) Finite Elements Methods (offered by CE dept)

Course Code	Semester	Course Title	Load	Credit
PCC-CH15	VII	Process EquipmentDesign-II	3L:1T:0P (06 hrs)	Credits:03

Prerequisite(s): Process Equipment Design-I

Course Objective: The objective of this subject is to introduce the undergraduate students with the most important separation equipments in the process industry, and provide proper understanding of unit operations. At the end of course the student will come to know basic design of process equipments.

Course content:

Module 1: (09 hrs)

Design criteria and scale up criteria of process equipment. Process design calculations for heat exchanges equipment double pipe and shell and tube heat exchangers general description, heat transfer coefficients and pressure drop by Kern's & Bell's methods rating on existing unit.

Module 2: (07 hrs)

Design of a new system having one or more units in series: single effect evaporator, multiple effect evaporators with boiling point elevation.

Module 3: (07 hrs)

Process design calculations for mass transfer equipment plate and Packed column for distillation.

Module 4: (10 hrs)

Process design calculations for Absorption and Adsorption including column diameter and height.

Module 5: (08 hrs)

Process and mechanical design for Flash drum, Kettle reboiler, condenser, cooling tower, rotary drier and tray drier.

Course Outcomes

After completion of this course, the students are able to:

CO1: Knowledge about process design calculations for heat exchanger.

CO2: Describe the concept about design of evaporators.

CO3: Design of packed column for distillation and absorption.

CO4: Design of utility equipments such as reboilers, rotary drier, tray drier etc.

Text Book:

1. Mahajani V. V., Umarji S.B., "Process Equipment Design", 4th Edition, MacMillan Pub, 2009.
2. Flynn A. M., Akashige T., Theodore L., "Kern's Process Heat Transfer", 2nd Edition, John Wiley & Sons, 2019.
3. Ludwig E, "Applied process design for chemical and petrochemical plants", Volume 1, 3^{r} Edition, Gulf professional Publishing, 1999.
4. Sinnott, R.K. , Coulson & Richardson's, "Chemical Engineering Design" 4th Edition, Volume 6, Elsevier, 2005.

Reference Book:

1. Perry, R..H., Green, D.W. & Maloney, J.O., "Perry Chemical Engineers Handbook", 7th Edition, McGraw-Hill, 1997.
2. Smith B. D; "Design of Equilibrium Stages" McGraw-Hill, 1963.

Course Code	Semester	Course Title	Load	Credit
PEC-CH 03 (A)	VII	Fluidization Engineering	3L:1T:0P (03 hrs)	Credits:03

Prerequisite(s): Fluid Mechanics, Fluid Particle Mechanics.

Course Objective: The objective of this subject is to introduce the undergraduate students with the basic principles of fluidization phenomena and practical aspects of fluidization operations for industrial application.

Course content:

Module 1: **(09 hrs)**

Introduction: The phenomenon of fluidization; Advantages and disadvantages of fluidizedbeds; Industrial applications of fluidized beds

Module 2: **(07 hrs)**

Hydrodynamics of Fluidization System: General bed behavior pressure drop, Flow regimes, Incipient fluidization, pressure fluctuations, phase holdups, Measurement techniques, Empirical correlations for solids holdup, liquid holdup andgas holdup, Flow models - generalized wake model, structural wake model and other important models.

Module 3: **(07 hrs)**

Characteristics of solids: Classification of solids; Flow characteristics and its outline in the different types of fluidization. Flow pattern of fluidization system: Frictional pressure drop, Solid movement, mixing, segregation and staging.

Module 4: **(10 hrs)**

Heat and Mass Transfer Fluidization Systems: Particle to gas mass transfer phenomena Heat transfer - Heat transfer between fluidized beds and surfaces and its analysis by model in two and three phase system

Module 5: **(09 hrs)**

Miscellaneous Systems: Moving bed, Slurry bubble columns, Two phase and three phase inverse fluidized bed, Bubbling fluidized beds, Entrainment and elutriation from fluidized beds, Design of fluidized bed reactors

Course Outcomes:

1. After completion of this course the student will be able to understand and learn
2. Basic concept and application of fluidization systems.
3. Hydrodynamics of Fluidization Syste
4. Solid Mixing and Segregation.
5. Heat and Mass Transfer Fluidization Systems
6. Design of fluidized bed reactors

Text Book:

1. Liang-Shih Fan, "Gas-Liquid-Solid Fluidization Engineering",Butterworths,1989.
2. Levenspiel O., Kunii D., "Fluidization Engineering", 2 nd edition, John Wiley, 1972
3. Yates J.G., "Fundamentals of Fluidized- Bed Chemical Process", Butterworths, 1983.

Reference Books:

Gidaspow, D., "Multiphase Flow and Fluidization", Academic Press, 199

Course Code	Semester	Course Title	Load	Credit
PEC-CH 03 (B)	VII	Plant Utility	3L: 1T: 0P (03 hrs)	Credit: 03

Prerequisite(s): Fluid Mechanics and Chemical Engineering Thermodynamics.

Course Objective: The objective of subject to understand the applications of boiler, turbine, insulation and design of chimney.

Module 1: (08 hrs)
Thermodynamics: Laws of perfect gases, thermodynamics processes, First and Second Law of thermodynamics, Entropy, The Clausius inequality, Steady Flow Processes, carnot Cycle. Properties of steam: Use of steam tables, measurement of dryness fraction, entropy of steam, temperature entropy and Mollier charts, Clausius Clapeyron equation, Rankine Cycle.

Module 2: (09 hrs)
Steam Generators: General Description, Boiler Mounting and Accessories, boiler heat recovery system, Natural and Artificial Draught, Equivalent Evaporation and Thermal efficiency. Fuels use in boilers — liquids, gaseous and hydrocarbon Pinch technology, design economics of turbine.

Module 3: (07 hrs)
Turbine: Theory and working of impulse, reaction and gas turbine. Bleeding and reheating. Introduction to refrigeration, various cycles, coefficient of performance. Applications of refrigeration

Module 4: (09 hrs)
Insulation: Importance of insulation for meeting for the process equipment, insulation material and their effect on various materials of equipment piping, fitting and valves, insulation for high, intermediate, low and subzero temperatures including cryogenic insulation, determination of optimum insulation thickness.

Module 5: (08 hrs)
Water: Sources, conditioning and management of water for cooling of hot gases, cooling towers, cooling ponds. Design of chimney. Constructional details and design aspects.

Course Outcomes:
After completion of this course, the students are able to…
CO1: Understand the application of laws of thermodynamics.
CO2: Discuss about boilers and its applications.
CO3: Describe theory and working of turbine and refrigeration.
CO4: Knowledge about the types of insulation, fitting and valves.
CO5: Understand the application of Plant Utility.

Text Book:

1. Howell J. R., Buckius R. D., "Fundamental of Engineering Thermodynamics", 2nd Edition, McGraw-Hill, 1987.
2. Cengel Y. A., Boles M. A., "Thermodynamics: An Engineering Approach", 8th edition, McGraw-Hill, 2017.
3. Broughton J., "Process utility systems : Introduction to design, operation, and maintenance
4. Rugby", Warwickshire, 1994.
5. Joel R. N., "Basic Engineering Thermodynamics", Longman, 1996.

Reference Books:

1. Eastop T.D., Conkey A. Mc.,"Applied Thermodynamics for Engineering Technologists, Pearson India", 2002.

Course Code	Semester	Course Title	Load	Credit
PEC-CH 03 (C)	VII	Chemical Project Engineering & Economics	3L:1T:0P (03 hrs)	Credits:03

Prerequisite(s): Chemical Process Calculation, Process Equipment Design I & II.

Course Objective: To provide the comprehensive knowledge of Chemical Project Engineering and Economics

Module 1:
Scope of project engineering, the role of project engineer, preliminary report writing of project, plant location and site selection, preliminary data for construction projects, process engineering, flow diagrams, plot plans, engineering design and drafting.

Module 2:

Planning and scheduling of projects- bar chart and network techniques, procurement operations, office procedures, contracts and contractors, project financing, statutory sanctions

Module 3:

Details of engineering design and equipment selection- design calculations excluded vessels, heat exchangers, process pumps, compressors and vacuum pumps, motors and turbines, other process equipment.

Module 4:

Cost and asset accounting, Product cost estimation, Cash Flows, Time value of money, investment costs, sales, profits, taxes, Depreciation Classification of Depreciation. Economic feasibility of project using order-of magnitude, plant and equipment cost estimation, balance sheet, and profit and loss account. Financial ratio analysis,

Module 5:

Input/output structure of the flow sheet, Recycle structure of the flow sheet; Separation system, Heat Exchanger Networks. Process design development and general design considerations.

Course Outcomes:
After completion of this course, the students are able to:
CO1. Bridges boundaries between engineering and chemical industry management.
CO2. Provide the students with a basic understanding and importance of design of chemicalplants.
CO3. Understand the responsibilities of project engineer, which includes schedule preparation, pre-planning and resource forecasting for engineering and other technicalactivities relating to the project.
CO4. Understand the Product cost estimation and Economic feasibility of project.
CO5. Understand the Input/output structure of the flow sheet and Process design developmentand general

design considerations.

Text Book:

Douglas, J. M., "Conceptual Design of Chemical Processes" , 3rd edition , McGraw-Hill, 1989.
Peters, M. S., Timmerhaus, K. D., "Plant Design and Economics for ChemicalEngineers," 4th edition, McGraw-Hill, 1991.
Biegler, L., Grossmann, I. E., Westerberg, A. W., "Systematic Methods of ChemicalEngineering and Process Design", Prentice Hall, 1997.

Reference Book:

Rase & Barrow, "Project Engineering of Process Plants", 99th Edition , John Wiley, 1957.

Course Code	Semester	Course Title	Load	Credit
PEC-CH 04(A)	VII	Advanced separation process	3L:1T:0P (04 hrs)	Credits:03

Prerequisite(s): Chemical Process Calculation, Mass transfer.

Course Objective: The objective of this subject is to introduce the undergraduate students with the most important separation equipments in the process industry, and provide proper understanding of unit operations.

Course content:

Module 1: **(09 hrs)**

Fundamentals of separation processes; Membrane based separation processes; classifications; Design aspects, Membrane separation technique: Principles, mechanisms, cross flow, Classification, application & advantages of membrane separation processes, Material of construction and manufacturing process of membrane.

Module 2: **(07 hrs)**

Reverse Osmosis: Concept of osmosis and reverse osmosis, different types of membrane modules and membrane material for R.O., Zero liquid discharge RO, Advantages and commercial applications of R.O. Ultrafiltration and nano filtration: Concept & working principle, Commercial applications of ultrafiltration and nano filtration

Module 3: **(07 hrs)**

Pressure Swing Adsorption: Concept & Working, Advantages & Disadvantages of PSA over cryogenic distillation, Purification of hydrogen, oxygen, Nitrogen & other commercial applications of PSA, Concept & Working of Pressure Swing Distillation

Module 4: **(10 hrs)**

Ion Exchange: basic principle and mechanism of separation, Ion exchange resins, regeneration and exchange capacity. Exchange equilibrium, affinity, selectivity andkinetics of ion exchange. Design of ion exchange systems

Module 5: **(09 hrs)**

Supercritical fluid extraction-Super Critical Extraction Working Principal, Advantage & Disadvantages of supercritical solvents over conventional liquid solvents, Advantage & Disadvantages of supercritical extraction over liquid- liquid extraction, Commercial applications of supercritical extraction.

Course Outcomes:

After completion of this course, the students are able to:

CO1: Classify Design aspects of Membrane separation technique

CO2: Define types of membrane modules and membrane material for R.O.

CO3: Describe the concept and working of Pressure Swing Adsorption.

CO4: Apply and working of Ion exchange.

CO5: Understand the application of Supercritical fluid extraction.

Text Book:

1.Kaushik N., "Membrane separation Processes",2nd Edition, PHI Publication, 2017.
2.McHugh, M. A., Krukonis V. J., "Supercritical Fluid Extraction: Principles and Practice", 2nd Edition, Butterworth-Heinemann Press, 1994.
3.Wankat, W. C., "Large Scale Adsorption and Chromatography", CRC Press, 1986.

Reference Book:

1.Rousseau, R.W. "Handbook of Separation Process Technology", John Wiley & Sons. 1987.
2.Perry, R.H., Green, D.W., Maloney, J.O., "Perry Chemical Engineers Handbook", 7th Edition, McGraw-Hill, 1997

Course Code	Semester	Course Title	Load	Credit
PEC-CH 04 (B)	VII	Catalysis	3L:1T:0P (04 hrs)	Credits:03

Prerequisite(s): Chemical reaction engineering

Course Objective: The objective of this subject is to introduce the undergraduate students with Concepts related to homogeneous and heterogeneous catalysis**,** Catalysts Characterization and preparation.

Course content:

Module 1: (09 hrs)

Concepts related to homogeneous and heterogeneous catalysis, Basic information about natural catalysis, bio-catalysis, and artificial catalysis, catalysts preparation methods - Laboratory Techniques, Zeolites, Enzymes, Solid Catalysts, Powder Catalysts, Pellets, Composition, Active ingredients, Supportive materials, Catalysts activation, Case study of V_2O_5 catalyst.

Module 2: (07 hrs)

Catalysts Characterization: Bulk density, Thermal stability, Surface area measurements, BET Theory, Pore size distribution, Chemisorption techniques, Crystallography and surface analysis techniques, XRD, XPS, techniques for catalyst characterization.

Module 3: (07 hrs)

Theories of Catalysts: Crystal structure and its defects, Geometric and electronic factors, Analysis of transition model catalysis, Chemistry and thermodynamics of adsorption, Adsorption isotherms – Langmuir model, Freundich model, Langmiur Hinshel-wood model, Rideal -Eely mechanism, Determination of rate controlling steps, Inhibition

Module 4: (10 hrs)

Mass and Heat Transport in Porous Catalysts: Internal and external transport, fixed bed, Fluidized bed reactors, Effect of internal transport on selectivity. Effectiveness factor and Thiele modulus

Module 5: (09 hrs)

Catalyst Deactivation: Poisons, sintering of catalysts, Kinetics of deactivation, Catalyst regeneration, Transition metal and its properties.

Course Outcomes:

After completion of this course the student will be able to understand and learnCO1. Catalyst types, synthesis methods.

CO2: Catalyst characterization.

CO3: Theories of catalysis.

CO4: Detailed modeling of industrial catalytic systems.

CO5: Catalyst Deactivation and its regeneration.

Text Book:

1. Satterfield, C.N.,"Heterogeneous Catalysis in Industrial Practice", 2nd Edition, KriegerPub. Co., 1996.
2. Emmett, P.H., "Catalysis Vol. I and II, Reinhold Corp", New York, 1955.

Reference Book:

Smith, J.M., "Chemical Engineering Kinetics", 2nd Edition, McGraw Hill, 1981.

Course Code	Semester	Course Title	Load	Credit
PEC-CH 04 (C)	VII	Polymer Technology	3L:1T:0P (04 hrs)	Credits:03

Prerequisite Course: Engineering Chemistry

Course Objective: To provide the comprehensive knowledge of different types of polymers and its application.

Module 1: **(08 hrs)**

Polymerization Chemistry: Chain, step and miscellaneous polymerization reactions and polymerization technique. Polymerization kinetics: Free radical, cationic and anionic polymerization, poly-condensation and polymerization.

Module 2: **(09 hrs)**

Polymerization Processes: Bulk solution, emulsion and suspension polymerization, thermoplastic composites, fiber reinforcement fillers, surface treatment reinforced thermo-set composites resins, fillers, additives.

Module 3: **(06 hrs)**

Polymer reactions: Hydrolysis, acidolysis, aminolysis, hydrogenation, addition and substitution reactions, reactions of various specific groups, cyclyzation and cross linking reactions, reactions leading to graft and block copolymer.

Module 4: **(07 hrs)**

Manufacturing processes of important polymers: Plastics- polyethylene, polypropylene, recycling of polypropylene (PP), Polyesters (Dacron). Acrylic-olefin, polyvinyl chloride & copolymer, polystyrene; Phenol-formaldehyde, epoxides, urethane, Teflon, elastomers, robbers, polymeric oils - silicon fibers - cellulosic (Rayon), polyamides (6:6 Nylon), Strength, properties and testing methods of polymers.

Module 5: **(08 hrs)**

Composite materials - Ceramic and other fiber reinforced plastics, Polymer degradation - Thermal, Mechanical, Ultrasonic, Photo, High energy radiation, Ecology and environmental aspects of polymer industries.

Course Outcomes:

After completion of this course, the students are able to:

CO1: Understand the principle of polymerization chemistry.

CO2: Know emulsion and suspension polymerization and thermoplasticcomposites.

CO3: Define polymer reaction like hydrolysis, aminolysis, hydrogenation etc.

CO4: Explain manufacturing processes of important polymers.

CO5: Recognize composite materials, polymer degradation, ecology andenvironmental aspects of polymer industries.

Text Book:

1. Ferdinand R. , Christopher C.C.,, Lynden K. O., Archer A.; “Principles of polymer systems”, 6th Edition, Taylor and Francis group, 2015.
2. Billmayer , Fred W., “Textbook of polymer science”, 3rd Edition; Wiley tappon,2007.

Reference Book:

1. Williams D. J., "Polymer science & engineering", 3rd Edition; Prentice Hall, 1971.
2. Tadmor Z., Costasge G., "Principles Of Polymer Processing", 2rd Edition, John Wiley & Sons,2006