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 VI (Third Year)

S. No.	Course Code	Course Title	Hrs./ week			Credits
			L	**T**	**P**	
1	PCC-CH601	Chemical Reaction Engineering-II	3	1	0	4
2	PCC-CH602	Chemical Process Control	3	1	2	4
3	PCC-CH603	Process Equipment Design-I	3	1	0	4
4	PEC-CH601	Professional Elective-II	3	1	2	4
5	OEC-CH601	Professional Open Elective-II	3	1	0	4
6	PCC-CH604	Simulation Lab-II	0	0	4	2
		Internship (90 hours internship to be completed during V or VI semester and its evaluation to be added in seventh semester)				0
Total			**15**	**05**	**08**	**22**
Total academic engagement and credits			**28**			**22**

	Professional Elective-II	Professional Open Elective-II
1	Chemical Process Modeling & Simulation	Foreign Language: German/French
2	Biochemical Engineering	Business Communication
3	Environment Pollution and Control	Stress Management
4	--	Soft Skill and Interpersonal Communication

Course Code	Semester	Course Title	Load	Credit
PCC-CH601	VI	Chemical Reaction Engineering-II	3L:1T:0P(04 hrs)	Credits:04

Prerequisite Course: Chemical Reaction Engineering-I

Course Objective: To provide the knowledge of Heterogeneous Catalysis & Reactor Design.

Module 1: **7 hrs**

Heterogeneous processes: Classification of catalysts, Preparation of catalysts, Promoters and Inhibitors, poisoning, General mechanism of catalytic reactions, kinetics of catalyst deactivation.

Module 2: **8 hrs**

Global reaction rate, External transport processes and their effects on heterogeneous reactions, Effect of external resistance on selectivity, effectiveness factors, Effect of intra-phase transport, Thiele Modulus.

Module 3: **9 hrs**

Design of Heterogeneous catalytic reactors: fixed bad reactor, Fluidized bed reactors, Gas liquid reaction on solid catalysts in slurry reactor.

Module 4: **8 hrs**

Models for fluid - solid non-catalytic reactions, controlling mechanisms, Diffusion through gas film controls. Diffusion through ash layer controls.

Module 5: **7 hrs**

Gas-liquid reactions and liquid-liquid reaction, Rate equation based on film theory, Rate equation for mass transfer and reaction.

Course Outcome:

CO1: Ability to understand mechanism of catalytic reactions.

CO2: Ability to understand External Diffusion and Internal diffusion in porous catalyst.

CO3: Ability to design catalytic reactor, Slurry Reactors, Trickle bed reactors fixed bed and fluidized bed reactors.

CO4: Ability to develop model for fluid solid non catalytic reactions.

CO5: Ability to understand Gas-Liquid Reactions and Liquid- Liquid Reaction based on film theory.

Text/Reference Book:

1. Fogler, H. S., "Elements of Chemical Reaction Engineering," 3rd ed., Prentice-Hall of India, Delhi, 2003.
2. Levenspiel, O., "Chemical Reaction Engineering," 3rd ed., John Wiley, 1999.
3. Smith, J. M., "Chemical Engineering Kinetics," 3rd ed., McGraw-Hill, 1981.
4. Carberry, J. J., "Catalytic Reaction Engineering," McGraw-Hill, 1976.
5. Levenspiel, O., "The Chemical Reactor Omnibook," OSU Bookstores, Corvallis Oregon, 1996.

Course Code	Semester	Course Title	Load	Credit
PCC-CH602	VI	Chemical Process Control	3L:1T:0P (04 hrs)	Credits:04

Prerequisite Course: Mathematics-II

Course Objective

The objective this course enables the students to know about control methods and make the students knowledgeable in various types of measuring instruments used in chemical process industries.

Module 1: 7 hrs

Construction and characteristics of final control elements such as Proportional, Integral, PD, PID controllers, pneumatic control valve, principles and construction of pneumatic and electronic controllers.

Module 2: 7 hrs

Process instrumentation diagrams and symbols, process instrumentation for process equipments such as Distillation column Absorption column, Heat Exchanger, Reactors, Evaporators, fluid storage vessels.

Module 3: 8 hrs

Laplace Transform, Linear open loop system, first order system and their transient response. Dynamic response of a pure capacitive process, Transportation lag, Dynamic response of a first order lag system, Block diagram reduction.

Module 4: 9 hrs

Second order system and their transient response. Interacting and non-interacting system. Linear closed loop system, block diagram of closed loop transfer function, controllers, transient response of closed loop system, Inverse response.

Module 5: 9 hrs

Stability concept, Routh stability criterion, relative stability, Hurwitz stability criterion, Nyquist's stability criterion. Root locus technique, introduction to frequency response, Bode diagram, Bode stability criterion, gain and phase margins, Ziegler Nichols controller setting, Cascade control system.

Course Outcomes:

CO1: Ability to understand the behavior of PID controller.
CO2: Ability to determine the step response for interacting and non interacting system.
CO3: Ability to understand the characteristic of control valve.
CO4: Ability to calibrating curve for thermocouple.
CO5: Ability to understand the stability of the process.

Text/Reference Book:

1. Coughnower & Koppel – Process System Analysis and Control- McGraw Hill, New York.
2. D. P. Eckman – Automatics Process Control – McGraw Hill, New York.
3. Peter Harriot – Process Control – McGraw Hill, New York. 4. J. J. Nagrath & M. Gopal; Control System Engineering.

List of Experiment (Pl. expand it):

1. To study the characteristics of control valves (linear, quick opening, etc)
2. To study the dynamics of liquid level systems of non-interacting and interacting types.
3. To study the response of mercury in glass thermometer with and without a thermowell.
4. To study the characteristics of an electronic PID controller.
5. To study the characteristics of a current to pneumatic converter.
6. To study the effectiveness of computer control of a distillation column.
7. To study the effectiveness of a computer control of a heat exchanger.
8. To study to effectiveness of a computer control of a chemical reactor
9. To study to dynamics of a pressure tanks.
10. To calibrate an air purged liquid level indicator.

Note: Each student should perform at least eight experiments out of the above list

Course Code	Semester	Course Title	Load	Credit
PCC-CH603	VI	Process Equipment Design-I	3L:1T:0P (04 hrs)	Credits:04

Prerequisite Course: Engineering Mechanics

Course Objective

The objective of this course is to acquire basic understanding of design parameter, complete knowledge of design procedures for commonly used process equipment and their attachments (e.g. internal and external pressure vessels, tall vessels, high pressure vessels, supports etc.), and different types of equipment testing methods.

Module 1: 8 hrs

Mechanics of materials- Stress- Strain relationships of elastic materials subjected to tensile, compressive and shear forces, Elastic and plastic deformation, General design considerations; Design of shell, bottom plates, self supported, and column supported roofs, wind girder, nozzles and other accessories.

Module 2: 9 hrs

Unfired pressure vessel- Pressure vessel codes, classification of pressure vessels, Design of cylindrical and spherical shells under internal and external pressures; Selection and design of flat plate, tor-spherical, ellipsoidal, and conical closures, compensations of openings. High pressure Vessels: Stress analysis of thick walled cylindrical shell.

Module 3: 11 hrs

Tall vertical & horizontal vessels-Pressure, dead weight, wind, earthquake and eccentric loads and induced stresses; combined stresses, Shell design of skirt supported vessels. Vessel supports; Design of skirt, lug, and saddle supports.

Module 4: 9 hrs

Bolted Flanges- Types of Flanges, and selection, Gaskets, Design of non- standard flanges, specifications of standard flanges. Fabrication of Equipment; major fabrication steps; welding, non-destructive tests of welded joints, inspection and testing, vessel lining, materials used in fabrication of some selected chemical industries.

Course outcome-

CO1: Ability to understand basic concepts of equipment design

CO2: Ability to understand design of cylindrical and spherical shells under internal and external pressures.

CO3: To provide knowledge about design of tall vertical & horizontal vessels.

CO4: To provide knowledge about design of flanges.

Text/Reference Book:

1. Brownell, N.E and Young, H.E; Process Equipment Design; John Wiley
2. Bhattacharya, B.C; Introduction of Chemical Equipment Design; CBS Publishers, Delhi.
3. Perry RH; Hand book of Chemical Engg; Mc Graw Hill Pub
4. I.S.: 2825-1969 – Code For Unfired Pressure Vessels.
5. Joshi, M.V.; Process Equipment Design.
6. ASME Boilers and Pressure Vessel codes.

Course Code	Semester	Course Title	Load	Credit
PEC-CH604(1)	VI	Chemical Process Modeling & Simulation	3L:0T:2P (05hrs)	Credits:04

Prerequisite: Chemical reaction engineering, mass transfer operation, heat transfer, thermodynamics.

Course Objective: To study Modeling and simulation of the chemical processes.

Module 1: **8 hrs**

Introduction to modeling, systematic approach to model building, conservation equations, constitutive equations, classification of models. Conservation principles, Advantages, limitations and application of simulation.

Module 2: **10 hrs**

Non-Reacting Liquid Systems: equation of continuity, application of the model equations, component mass balances, model behavior: steady state behavior, un-steady state behavior, Reacting Liquid Systems: Development of steady state and dynamic lumped and distributed parameter models based on first principles, Development of model of CSTR, Batch reactor, parallel and series reaction, pseudo first-order reactions, reversible reactions, consecutive reaction.

Module 3: **8 hrs**

Treatment of experimental data: Introduction, criteria for Best Fit, Best Slope-I, Best, Slope-II, Best straight line, fitting a quadratic, simulation examples of gravity fluid flow, Monte-Carlo simulation

Module 4: **7 hrs**

Development of model of Heat transfer equipment, Batch and continuous Distillation sequential, simultaneous modular and equation oriented approaches, partitioning and tearing.

Module 5: **7 hrs**

Computer programming of various iterative convergence methods such as Newton-Raphson, False position, Wegstein, Muller methods.

Course Outcomes:

CO1: Evaluate chemical engineering problems & basic concepts of model equations.
CO2: Ability to get knowledge about model development for Non-reacting and reacting Liquid systems.
CO3: Analyze the experimental data using Best Fit, Best Slope method.
CO4: Application of dynamic modeling of simple processes, modular and equation oriented approaches, tearing of algorithm.
CO5: Study and apply various iterative convergence methods.

List of Experiments:

1. Process dynamics experiments like flow of incompressible fluids at a variable flow rate.
2. Dynamics of a tank draining through an orifice in the bottom. Differential equation formulation and verification with the experimental data.
3. Mass balance in a tank filling at certain rate and emptying at another rate. Rectangular and wedge-shaped tank and incompressible fluid.
4. Modeling a batch reactor-verification of 151 and 2nd order rate kinetics.
5. Counter current double pipe heat exchanger modeling-data analysis by iterative methods.
6. Simulation of a distillation column-binary systems, equi-molal overflow, constant relative, volatility.
7. Input-Output response study in non-ideal flow reactors.
8. Simulation of a perfectly mixed reactor with heat transfer. Derivation of a mathematical model and solving for study state heat transfer.

Text/ Reference Book:

1. Russell TWF; Introduction to Chemical Engineering Analysis -John Wiley & Sons
2. Luyben W.L; Process Modeling, Simulation And Control For Chemical Engineers; TMH
3. Jana ; Chemical process modeling and computer simulation; PHI Learning.

Course Code	Semester	Course Title	Load	Credit
PEC-CH604(2)	VI	Biochemical Engineering	3L:1T:P 0(04 hrs)	Credits:04

Prerequisite(s): Chemical Reaction Engineering, Physical Chemistry, Mass transfer operations

Module 1: 7 hrs

Introduction to Microbilogy and Bio-Chemical Engineering: Role of chemical engineers in biotechnology, Aspects of microbiology, cell theory structure of microbial cells, classification of microorganism, Essential chemicals of life lipids, Sugars and Polysaccharides, RNA and DNA, Amino acids and proteins.

Module 2: 9 hrs

Metabolism and Energetic: Assimilatory and dissimilatory process, metabolic mechanism of the cells; Biochemical Kinetics: Simple enzyme kinetics with one or two substrates, Mechanism of Enzyme action, inhibition and regulation, modulation of enzymatic activity, enzyme reactions in heterogeneous systems, immobilization of enzyme.

Module 3: 6 hrs

Microbial growth: Kinetics of microbial growth, Growth cycle, phases for Batch cultivation, mathematical modeling of batch growth, products synthesis Kinetics, overall kinetics and thermal death kinetics of cells and spores.

Module 4: 9 hrs

Unit Operations in Biochemical Process: Agitation and aeration, gas liquid mass transfer, determination of oxygen transfer rates, determination of Kga and KLa scaling of mass transfer equipment, heat balance and heat transfer correlation for biochemical systems, sterilization, filtration and drying.

Module 5: 9 hrs

Design and Analysis of Bio-Reactors: Classification and characterization of different bioreactors, batch and continuous reactors, tubular, CSTR and tower reactors, aerobic and anaerobic fermentation-process, design and operation of typical aerobic and anaerobic fermentation processes, manufacture of microbial products e.g. antibiotics alcohol/ wine etc; use of whole cells for industrial processes.

Course Outcomes:

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

CO1: Understand fundamental concept of biochemical engineering, cell theory structure of microbial cell, essential chemicals of life-lipids, sugars, proteins etc.

CO2: Derive expression for biochemical kinetics, enzyme reactions in heterogeneous system

CO3: Understand growth cycle, phases for batch cultivation and develop mathematical model of batch growth.

CO4: Understand and analyze unit operations in biochemical process

CO5: Design and analyze bioreactors, fermentation process

Text/Reference Book:

1. J. E. Bailey and D. F. Ollis, Biochemical Engineering Fundamentals, McGraw Hill
3. Shuler, Kargi; Bioprocess Engineering basic concepts.; PHI Learning
4. Inamdar S.T , Biochemical Engineering – Principles and Concepts.A
5. Rao ; Introduction to Biochemical Engineering; TMH

Course Code	Semester	Course Title	Load	Credit
PEC-CH604(3)	VI	Environmental pollution and control	3L:1T:P 0(04 hrs)	Credits:04

Module 1: **7 hrs**

Environmental Pollution: Concept of pollution, causes of environmental pollution, Environmental problems due to pollution, concept of Development, Major conflicts of Development and Environment, Mining and Environment.

Module 2: **8 hrs**

Air Pollution: Sources and effect of air pollution, classification of air pollutants, emission standard of air pollution. Meteorological condition influencing air pollution, Chemical inversion, principle, working principle of control equipment for particulate emission and gaseous pollutants like cyclone separator, gravity settling chamber, multi-tray settling chamber, bag filter, scrubber, E.S.P.

Module 3: **9 hrs**

Water Pollution: Sources and effect of water pollution, water born diseases, classification of water pollutants, physical, chemical and bacteriological analysis of water; pollution laws and limits, effluent standards;, working principle of waste water and industrial effluent treatment plants (physiochemical and biological)

Module 4: **9 hrs**

Advance Waste water treatment: Advanced oxidation process; photolysis and photocatalysis, sonolysis, electrochemical oxidation technologies, Fenton-based processes and ozone-based processes: Membrane Technology; Principles of Membrane processes; Types and uses of membranes; Recent development in membranes; Types and uses of modules; Washing procedures, Membrane bioreactors; Pervaporation and its applications; Reverse Osmosis, Ultrafiltration and Microfiltration and their applications; Dialysis and Electrodialysis and their applications; Others.

Module 5: **7 hrs**

Pollution due to solid waste and Noise : Sources and effects of solid waste and Nature of domestic, municipal, agricultural, industrial, Hospital, Nuclear Wastes; collection, treatment and disposal of solids waste; waste recovery system, solid waste management; Sources and effects of noise pollution noise pollution, noise measurement and control; noise mitigation measures.

Course Outcomes

CO1: Ability to understand the concept of pollution and their effect on human, plants and animals.

CO2: Knowledge about source and effect of air pollution and their solutions.

CO3: Understanding about source and effect of water pollution and their solutions.

CO4: Ability to design modern technique for waste water treatment.

CO5:Ability to understand solid waste and noise pollution.

Text/Reference Book:

1. Rao C S; Environmental Pollution Control Engineering; New Age India Ltd.
2. Mahajan S P; Pollution Control in Process Industries
3. Canter Lary; Environmental Impact Assessment; TMG
4. Keily; Environmental Engineering; TMG
5. Miller GT Jr; Environmental sciences-working with earth; Cegage Pub.

Course Code	Semester	Course Title	Load	Credit
OEC-CH606	VI	Simulation Lab- II	L:T:4P (04 hrs)	Credits:02

Simulation Study of Various Chemical Process with the help of Software : ChemCAD