Course code	Course Name	L-T-P-Credits	Year of Introduction
CH308	**CHEMICAL REACTION ENGINEERING-II**	**3-0-0-3**	**2016**

Prerequisite : CH305 Chemical reaction engineering - I

Course Objectives

- To expose the students to the concepts of non-ideal flow and flow models, kinetics and reactor design for heterogeneous reactions and design aspects of non-isothermal operations.

Syllabus

Non Ideal flow, RTD studies, Models for non-ideal flow. Kinetics and design of catalytic and non-catalytic heterogeneous reactions. Non-Isothermal reactor operation, Energy Balance, Adiabatic and non adiabatic operations.

Expected outcome

At the end of the course, students will be able to

i. Understand non ideal behaviour of chemical reactors.
ii. Set up and solve non ideal flow models using RTD studies.
iii. Analyze the kinetics and design aspects of catalytic and non-catalytic heterogeneous reactions.
iv. Set up and solve energy balances for non-isothermal operation of chemical reactors.
v. Design chemical reactors for non-isothermal operations.
vi. Develop an awareness of stability and safety of chemical reactors

References Books:

1. H Scott Fogler, "Elements of Chemical Reaction Engineering", Prentice Hall of India.
2. James J Carberry, "Chemical &Catalytic Reaction Engineering", Mc Graw Hill
3. K.G Denbigh& J.C.R Turner, 'Chemical Reactor Theory- An Introduction', Cambridge University Press
4. Lanny D Schmidt, 'The Engineering of Chemical Reactions, 'Oxford University Press.
5. Levenspiel Octave , "Chemical Reaction Engineering", John Wiley & Sons.
6. Ronald W. Missen, Charles A. Mims, Bradley A. Saville, 'Introduction to Chemical Reaction Engineering and Kinetics', John Wiley & Sons
7. Smith J.M, "Chemical Engineering Kinetics," McGraw Hill.

Module	Contents	Hours	Sem. Exam Marks
I	Non-ideal Flow. Residence time distribution for chemical reactors: General characteristics - RTD functions. Measurement of the RTD - pulse input, step tracer input, integral relationships, mean residence time, other moments of the RTD, Normalized RTD function E(theta), Interval age distribution. RTD in ideal reactors: Batch and plug flow reactors, single CSTR, Laminar flow reactor,PFR /CSTR series reactor	6	15%

II	Reactor modelling with RTD - use of RTD to determine conversion. RTD models - segregation models, tanks in series model, the dispersion model. Conversion for the tanks-in-series model, fitting the dispersion model for small extents of dispersion and large extents of dispersion. Models for small deviations from plug flow and long tails. Mixing of fluids - self mixing of fluids - degree of segregation, early and late mixing of fluids	6	15%
FIRST INTERNAL EXAMINATION			
III	Catalyst and catalytic reactors: Catalysts, types of catalysts, catalytic properties, steps in a catalytic reaction, adsorption equilibrium constant, desorption, surface reaction, synthesizing rate law, rate limiting step, Langmuir-Hinshelwood approach. Development of design equations for ideal mixed batch reactor, plug flow tubular reactor and perfectly mixed continuous stirred tank reactor for heterogeneous systems. Heterogeneous data analysis for reactor design	7	15%
IV	Diffusion and reaction in porous catalysts- effective diffusivity, tortuosity-modelling of diffusion with reaction on a spherical catalysts. Thiele Modulus, internal effectiveness factor, Overall effectiveness factor. Estimation of diffusion and reaction limited regimes - Weisz - Prater criterion for internal diffusion, Mears criterion for external diffusion.	7	15%
SECOND INTERNAL EXAMINATION			
V	Fluid Particle Reactions (Non catalytic) Selection of a model: Unreacted core model for spherical particles of unchanging size, model development for diffusion through gas film, ash layer, and chemical reaction controls. Rate of reaction for shrinking spherical particles - chemical reaction controls, diffusion controls, application to design. Fluid-fluid reactions - Rate equations, Kinetic regimes for mass transfer and reactions, rate equation for instantaneous and fast and slow reactions,.	8	20%
VI	.Non isothermal reactor design - Temperature and pressure effects - single reactions : Heat of reaction from thermodynamic, heat of reaction and temperature, equilibrium constants from thermodynamics. General graphical design procedure, optimum temperature progression. Heat effects: adiabatic operations and non-adiabatic operations : Energy Balance, Non-isothermal continuous flow reactors at steady state, application to the CSTR, adiabatic tubular and batch reactor, steady state tubular reactor with heat exchange. Equilibrium Conversions, Adiabatic Equilibrium conversion, reactor staging. Multiple Steady States in CSTR.	8	20%
END SEMESTER EXAMINATION			

Question Paper Pattern

Maximum Marks: 100 Exam Duration: 3 Hours

Part A: There shall be **Three questions** uniformly covering Modules 1 and 2, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in each main question with a total of 15 marks for all the subdivisions put together. (2 x15= 30 Marks)

Part B: There shall be **Three questions** uniformly covering Modules 3 and 4, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in each main question with a total of 15 marks for all the subdivisions put together. (2 x15= 30 Marks)

Part C: There shall be **Three questions** uniformly covering Module 5 and 6, each carrying 20 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in each main question with a total of 20 marks for all the subdivisions put together. (2 x20= 40 Marks)