Course code	Course Name	L-T-P Credits	Year of Introduction
CH469	MATHEMATICAL METHODS IN PROCESS ENGINEERING	3-0-0-3	2016

Prerequisite : Nil

Course objectives:

1. To introduce different kinds of modelling equations in chemical engineering**.**
2. To gain the ability to solve the above equations of linear or nonlinear algebraic, ordinary differential equations and partial differential equations.
3. To appreciate the conditions of uniqueness of solutions of linear and nonlinear equations.
4. To study the effect of system parameters on stability of nonlinear systems.

Syllabus:

Introduction to modelling and simulation, vectors, matrices, Eigen values and Eigen vectors, solution methods for finite dimensional space (Algebraic Equations & Ordinary Differential Equations), solution methods for infinite dimensional space (Partial Differential Equations), Uniqueness conditions for Linear and Nonlinear Systems, Linear Stability and Limit Cycles Bifurcation Theory.

Expected outcome:

The students will be able to

i. Comprehend the behaviour of chemical engineering system from model equations.
ii. Understand the basis for each mathematical technique to solve the model equations
iii. Follow the models and simulation methods to analyse chemical engineering problems.
iv. Acquire the ability to use the simulation packages with a good understanding of mathematics behind it.

Text book:

- S. Pushpavanam, “Mathematical Methods in Chemical Engineering”, Prentice Hall of India Pvt. Ltd., 1998.

Reference books:

1. Gilbert Strang, “Linear Algebra and Applications”, Holden Day Publishers.
2. Irvin Kreyszig, “Advanced Engineering Mathematics”**,** New Age International (Pvt) Ltd., New Delhi.
3. T. K. V. Iyengar, B. Krishna Gandhi et al. “Mathematical Methods”, S. Chand and Company.

Course plan

Module	Contents	Hours	Sem. Exam Marks
I	Introduction to: Modelling, types of modelling, linear and non-linear equations, homogeneous and heterogeneous equations, simulation and types of simulation, mathematical methods: Numerical and analytical methods, examples for modelling equations in chemical engineering for: linear and nonlinear - algebraic, ordinary differential equation and partial differential equation.	5	15%

II	Vectors, vector spaces, Metrics, Norms, Inner products, Linear dependence anddimension. Gram- Schmidt Orthonormalisation. Matrices, Eigen values, Eigen vectors, Fredholm alternative. Applications to Chemical Engineering: Linear algebraic equations.	8	15%
FIRST INTERNAL EXAMINATION			
III	Applications to Chemical Engineering: Systems of first order homogeneous Ordinary Differential Equations (ODE) (IVP). First order non homogeneous ODE (IVP). Partial differential Equations: Classification of Second order partial differential equations. Linearity and superposition. Sturm- Louiville Theory	8	15%
IV	Infinite dimensional spaces, Eigen value problems, Classical Eigen value problems, Fourier Series, Rayleigh's Quotient. Separation of variables and Fourier Transforms: Rectangular Cartesian Coordinates. Cylindrical coordinates, Spherical coordinates, Fourier series and finite Fourier Transforms. Laplace Transform. Green's Function: Ordinary Differential Equations.	8	15%
SECOND INTERNAL EXAMINATION			
V	Uniqueness conditions for Linear and Nonlinear Systems. Maximum principle, Energy methods, Fredholm alternative, Monotone iteration method. Steady State Characteristics of Nonlinear Dynamical Systems: Dynamic systems, Steady state, Continuation methods.	7	20%
VI	Linear Stability and Limit Cycles: Linear Stability of Dynamical Systems. Bifurcation Theory, Maps. Secondary bifurcation and chaos:	6	20%
END SEMESTER EXAM			

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 one 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 Module 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 one 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 one main question with a total of 20 marks for all the subdivisions put together. (2 x20= 40 Marks)