Ahmedabad University

Course	MAT396 Numerical Methods	Semester	Monsoon Semester 2024
Faculty Name(s)	Gaurav Goswami	Contact	gaurav.goswami@ahduni.edu.in
School	SEAS	Credits	3
GER Category:	Mathematical and Physical Sciences	Teaching Pedagogy Enable:NO	P/NP Course: Can not be taken as P/NP

Schedule

Section 1	08:00 am to 09:30 am	Fri	01-08-24 to 26-11-24
	09:30 am to 11:00 am	Fri	01-08-24 to 26-11-24

Prerequisite	MAT203 Differential Equations and Linear Algebra OR MAT 246 Linear Algebra/MAT246 Linear Algebra & MAT 256 Differential Equations/MAT256 Differential Equations
Antirequisite	Not Applicable
Corequisite	Not Applicable
Course Description	This course is offered to all the UG/PG/PhD students who satisfy the prerequisites. Students should have a prior understanding of differential equations and Linear Algebra. The objective of this course is to find solutions for the system of linear equations, roots of non-linear equations, function approximation and interpolation, differentiation and integration, and solving Ordinary Differential Equations (ODEs) and Partial Differential Equations (PDEs). Besides learning the methods for algorithm development, MATLAB codes will be developed to solve mathematical problems. Towards the end of the course, students will solve term projects. To solve the term project, one requires a thorough understanding of Numerical Methods.

Course Objectives	Real-life problems can be modelled using Differential equations and Algebraic equations. Solving those mathematical models are very challenging depending upon the complexity. Numerical methods can give an approximate solution with the desired accuracy. Along with learning algorithms for the Numerical methods, this course helps in understanding the behaviour of Differential equations and Linear Algebraic equations.
Learning Outcomes	The immense learning outcomes, as listed below, of this course results from the powerfulness of the numerical methods in solving complex mathematical problems, thanks to the powerful computational capabilities of the mainframe computer and its availability. • Recalling the mathematical models developed for different physical systems/problems in the earlier courses of studies. • Translating those complex mathematical models into a solvable form of mathematical expressions, such as a set of linear algebraic equations, differential, and integral equations. • Application of the most suitable numerical method to solve the mathematical expressions for the solution of the mathematical model. • Analyse the results to understand the behavior of the physical systems. • Determine the significant variables responsible for the complex behavior of the system, and evaluate the accuracy and suitability of the numerical method at some extreme response of the model. • Predict the significant properties of a system for technology development.
Pedagogy	Lectures along with problem solving. The problem solving will include coding on MATLAB as well. Interested student will be encouraged to use other programming languages to develop codes.
Expectation From Students	Students are expected to attend all the classes. Active engagement in discussions in the class. Mandatory submission of all the assignments, term projects, appearing for the examinations and quizzes.

Assessment/Evaluation	• Mid-Semester Examination:
	  ◦ Written - 20%
	• End Semester Examination:
	  ◦ Written - 35%
	• Other Components:
	  ◦ Assignment - 15%
	  ◦ Project - 20%
	  ◦ Quiz - 10%

Attendance Policy	As per Ahmedabad University Policy.

Project / Assignment Details	Assignments will be of two types: (1) to solve using pen and paper, (2) solving through code development on MATLAB. A few students will be selected randomly by the instructor for every assignment on MATLAB to appear for the discussion on the code she/he developed. Students will also be involved in solving term projects in groups.
Course Material	Reference Book • Numerical Methods for Engineers, Steven C. Chapra Raymond P. Canale, Sixth Edition, McGraw Hill , Year: 2006,
Additional Information	• This course can be taken as a Major Core or Elective Core with approval from the programme chair. • This course can be considered as a credit course for the masters and Ph.D. with an additional course component, i.e., an additional project. • This course may be relevant for the students of B.Tech, BS (Honours) in Computer Science, Physics, Integrated masters of Life Sciences, and for the Ph.D. students of these programmes.

Session Plan

NO.	TOPIC TITLE	TOPIC & SUBTOPIC DETAILS	READINGS,CASES,ETC.	ACTIVITIES	IMPORTANT DATES
1	Introduction	Fundamentals of numerical computation; rounding errors; accuracy and precision	Steven C. Chapra Raymond P. Canale, Chapter 3		
2	System of linear Algebraic equations	Gaussian elimination; LU factorization	S K Gupta, Chapter 1	Assignment - 1	
3	System of linear Algebraic equations	Gauss Jordan elimination; Gauss-Siedel method	S K Gupta, Chapter 1		
4	System of linear Algebraic equations	Eigenvalues and eigenvectors of matrices; Power method	S K Gupta, Chapter 2	Assignment -2	
5	System of linear Algebraic equations	Householder's and Given's method	S K Gupta, Chapter 2		
6	Nonlinear Algebraic equations	Fixed point method. Newton Raphson method	S K Gupta, Chapter 3	Quiz - 1	
7	Nonlinear Algebraic equations	Secant method; Regula falsi; Bisection method	S K Gupta, Chapter 3	Assignment - 3	
8	Function approximation	Linear regression (least square curve fit)	S K Gupta, Chapter 4		
9	Function approximation	Newton's interpolation formulae; Newton's divide difference interpolation polynomial	S K Gupta, Chapter 4		
10	Function approximation	Lagrangian interpolation; Pade approximation	S K Gupta, Chapter 4		
11	Function approximation	Cubic spline approximation	S K Gupta, Chapter 4	Assignment - 4	

12	Differentiation	Differentiation formulae; Error analysis; Higher-order formulae	S K Gupta, Chapter 5		
13	Integration	Integration formulae and quadrature; Trapezoidal rules; Simpson's rules	S K Gupta, Chapter 5		
14	Integration	Closed Newton-Cotes integration; Gaussian quadrature	S K Gupta, Chapter 5	Assignment - 5	
15	Mid Term Examination				
16	Ordinary Differential Equation (Initial Value Problem)	Explicit Adams-Bashforth technique	S K Gupta, Chapter 5		
17	ODE (IVP)	Implicit Adams-Moulton techniques; Predictor-corrector techniques	S K Gupta, Chapter 5	Assignment - 6	
18	ODE (IVP)	Runge-Kutta methods	S K Gupta, Chapter 5	Term project	
19	ODE (IVP)	Semi-implicit Runge-Kutta techniques; Estimation of error; Stability of the algorithm	S K Gupta, Chapter 5		
20	ODE (IVP)	Stiffness of ODEs; Gear's technique for a stiff equation	S K Gupta, Chapter 5	Assignment - 7	
21	ODE (Boundary Value Problem)	The finite difference method	S K Gupta, Chapter 6	Quiz - 2	
22	ODE (BVP)	Orthogonal collocation technique	S K Gupta, Chapter 6		
23	ODE (BVP)	Shooting techniques	S K Gupta, Chapter 6	Assignment - 8	
24	Partial Differential Equation	Finite difference method; Crank-Nicholson Method	S K Gupta, Chapter 7	Assignment - 9	

25	Problem Solving	Problem Solving on MATLAB			
26	Problem Solving	Problem Solving on MATLAB			
27	Problem Solving	Problem Solving on MATLAB			
28	Reflection and Review				
29	Reflection and Review				
30	End Semester Examination				