Mathematics: DSE–2

Any *one* of the following:

DSE-2 (i): Numerical Methods

DSE-2 (ii): Differential Equations

DSE-2 (i): Numerical Methods

Total Marks: 100 (Theory: 75 and Internal Assessment: 25)
Workload: 5 Lectures, 1 Tutorial (per week) **Credits:** 6 (5+1)
Duration: 14 Weeks (70 Hrs.) **Examination:** 3 Hours.

Course Objectives: The goal of this paper is to acquaint students for the study of certain algorithms that uses numerical approximation for the problems of solving polynomial equations, transcendental equations, linear system of equations, interpolation, and problems of ordinary differential equations.

Course Learning Outcomes: After completion of this course, students will be able to:

i) Find the consequences of finite precision and the inherent limits of numerical methods.
ii) Appropriate numerical methods to solve algebraic and transcendental equations.
iii) Solve first order initial value problems of ordinary differential equations numerically using Euler methods.

Unit 1: Errors and Roots of Transcendental and Polynomial Equations
Floating point representation and computer arithmetic, Significant digits; Errors**:** Roundoff error, Local truncation error, Global truncation error, Order of a method, Convergence and terminal conditions; Bisection method, Secant method, Regula–Falsi method, Newton–Raphson method.

Unit 2: Algebraic Linear Systems and Interpolation
Gaussian elimination method (with row pivoting), Gauss–Jordan method; Iterative methods**:** Jacobi method, Gauss–Seidel method; Interpolation**:** Lagrange form, Newton form, Finite difference operators, Gregory–Newton forward and backward difference interpolations, Piecewise polynomial interpolation (Linear and quadratic).

Unit 3: Numerical Differentiation, Integration and ODE
Numerical differentiation**:** First and second order derivatives, Richardson extrapolation method; numerical integration**:** Trapezoidal rule, Simpson's rule; Ordinary differential equation**:** Euler's method, Modified Euler's methods **(**Heun's and midpoint).

References:

1. Chapra, Steven C. (2018). *Applied Numerical Methods with* MATLAB *for Engineers and Scientists* (4th ed.). McGraw-Hill Education.
2. Fausett, Laurene V. (2009). *Applied Numerical Analysis Using* MATLAB. Pearson. India.
3. Jain, M. K., Iyengar, S. R. K., & Jain R. K. (2012). *Numerical Methods for Scientific and Engineering Computation* (6th ed.). New Age International Publishers. Delhi.

Additional Reading:

i. Bradie, Brian (2006). *A Friendly Introduction to Numerical Analysis*. Pearson Education India. Dorling Kindersley (India) Pvt. Ltd. Third Impression, 2011.

Teaching Plan (DSE-2(i): Numerical Methods):

Weeks 1 and 2: Floating point representation and computer arithmetic, Significant digits; Errors**:** Roundoff error, Local truncation error, Global truncation error; Order of a method, Convergence and terminal conditions.

[2] Chapter 1 (Sections 1.2.3, 1.3.1, and 1.3.2).

[3] Chapter 1 (Sections 1.2, 1.3).

Week 3 and 4: Bisection method, Secant method, Regula–Falsi method, Newton–Raphson method.

[2] Chapter 2 (Sections 2.1 to 2.3).

[3] Chapter 2 (Sections 2.2 and 2.3).

Week 5: Gaussian elimination method (with row pivoting), Gauss–Jordan method; Iterative methods**:** Jacobi method, Gauss–Seidel method.

[2] Chapter 3 (Sections 3.1, and 3.2), Chapter 6 (Sections 6.1, and 6.2)

[3] Chapter 3 (Sections 3.2, and 3.4)

Week 6: Interpolation**:** Lagrange form, and Newton form.

[2] Chapter 8 (Section 8.1).

[3] Chapter 4 (Section 4.2)

Weeks 7 and 8: Finite difference operators, Gregory–Newton forward and backward difference interpolations.

[3] Chapter 4 (Sections 4.3, and 4.4).

Week 9: Piecewise polynomial interpolation**:** Linear and quadratic.

[2] Chapter 8 [Section 8.3 (8.3.1, and 8.3.2)].

[1] Chapter 18 (Sections 18.1 to 18.3)

Weeks 10, 11 and 12: Numerical differentiation**:** First and second order derivatives, Richardson extrapolation method; Numerical integration**:** Trapezoidal rule, Simpson's rule.

[2] Chapter 11 [Sections 11.1 (11.1.1, 11.1.2 and 11.1.4), and 11.2 (11.2.1, and 11.2.2)]

Weeks 13 and 14: Ordinary differential equations**:** Euler's method, Modified Euler's methods **(**Heun's and midpoint).

[1] Chapter 22 (Sections 22.1, 22.2 (up to Page 583) and 22.3).

Facilitating the Achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	Find the consequences of finite precision and the inherent limits of numerical methods.	(i) Each topic to be explained with examples. (ii) Students to be involved in discussions and encouraged to ask questions. (iii) Students to be given homework/assignments. (iv) Students to be encouraged to give short presentations.	• Presentations and participation in discussions. • Assignments and class tests. • Mid-term examinations. • End-term examinations.
2.	Appropriate numerical methods to solve algebraic and transcendental equations.		
3.	Solve first order initial value problems of ordinary differential equations numerically using Euler methods.		

Keywords: Bisection method, Euler's method, Gauss–Jordan method, Gauss–Seidel method, Jacobi method, Newton–Raphson method, Regula–Falsi method, Richardson extrapolation method, Secant method and Simpson's rule.