Numerical Computing

Course Roadmap — 45 Lecture Series

Module 1: Introduction and Error Analysis

Lectures 1–5

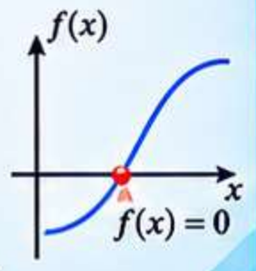
- Introduction to Numerical Computing
- Number Representation and Floating-Point Arithmetic
- Absolute, Relative and Percentage Errors
- Round-off, Truncation and Propagation of Errors
- Taylor Series, Stability and Convergence

$$E_r = \frac{|x - x^*|}{|x^*|}$$

Module 2: Solution of Nonlinear Equations

Lectures 6–12

- Graphical Method and Root Isolation
- Bisection Method
- Regula Falsi (False Position) Method
- Fixed-Point Iteration Method
- Newton–Raphson Method
- Secant Method
- Comparison and Convergence Analysis



Module 3: Systems of Linear Equations

Lectures 13–20

- Introduction to Systems of Linear Equations
- Gaussian Elimination Method
- Gaussian Elimination with Pivoting
- Gauss–Jordan Elimination Method
- LU Decomposition Method
- Jacobi Iterative Method
- Gauss–Seidel Iterative Method
- Diagonal Dominance and Convergence

$$Ax = b$$

$$A = LU$$

Module 4: Numerical Interpolation

Lectures 21–27

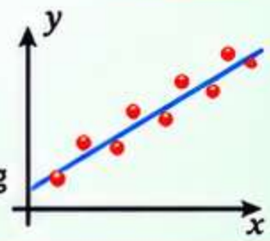
- Introduction to Interpolation and Extrapolation
- Finite Differences and Difference Tables
- Newton Forward Difference Interpolation
- Newton Backward Difference Interpolation
- Newton Divided Difference Interpolation
- Lagrange Interpolation
- Spline Interpolation and Interpolation Errors

$$P_n(x) = \sum_{i=0}^{n} y_i L_i(x)$$

Module 5: Curve Fitting and Approximation

Lectures 28–30

- Introduction to Curve Fitting and Least Squares Method
- Linear and Polynomial Curve Fitting
- Exponential, Logarithmic and Power Curve Fitting



$$y = a_0 + a_1 x + \cdots + a_n x^n$$

Module 6: Numerical Differentiation and Integration

Lectures 31–36

- Numerical Differentiation — Forward, Backward and Central Differences
- Higher-Order Numerical Differentiation
- Trapezoidal Rule
- Simpson's 1/3 Rule
- Simpson's 3/8 Rule
- Composite Rules, Romberg Integration and Error Analysis

$$f'(x) \approx \frac{f(x+h) - f(x)}{h}$$

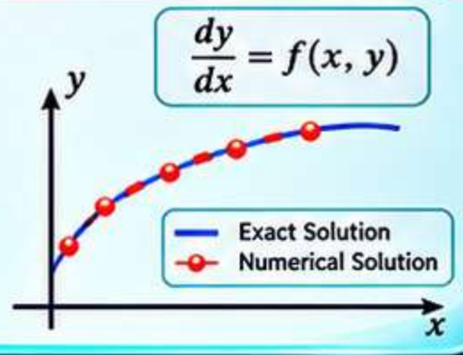
$$\int_a^b f(x dx \approx \frac{h}{2}(y_0 + 2\sum_{i=1}^{n-1} y_i + y_n)$$

Module 7: Numerical Solution of Differential Equations

Lectures 37–42

- Introduction to Ordinary Differential Equations
- Euler's Method
- Modified Euler's Method (Heun's Method)
- Second-Order Runge–Kutta Method (RK2)
- Fourth-Order Runge–Kutta Method (RK4)
- Predictor–Corrector Methods

$$\frac{dy}{dx} = f(x, y)$$

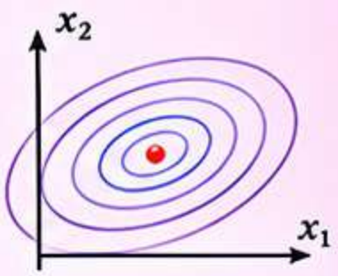


Module 8: Advanced Numerical Methods and Applications

Lectures 43–45

- Eigenvalues and Eigenvectors — Power Method
- Introduction to Numerical Optimization
- Computational Applications and Comprehensive Review

$$Av = \lambda v$$



45 Lectures • 8 Modules • From Foundations to Applications • Complete Course Roadmap