CE5225 - Numerical techniques in civil engineering

Credit Distribution: C:10 L:2 T:0 P:3 E:0 O:5 TH:0

Course Type: Others

Description: Apply concepts using linear algebra, optimization methods, regression and curve fitting, numerical integration and differentiation, and ordinary differential equations to solve typical civil engineering problems across disciplines. Develop computer programs in higher level programming languages such as Matlab/Python/R, using numerical techniques to solve civil engineering case study problems.

Course Content: Basics of computer programming: Variables, arrays, matrices, structures, if-then-else conditions, for and while loops, user defined functions, basic parallel programming, graphical plotting. Introduction: Framework for mathematical modeling, basics of Matlab/Python/R programming, computational errors (round off, truncation, and total numerical), model and data uncertainty, model accuracy and precision, applications in civil engineering. Roots and optimization: Graphical methods, fixed-point iteration, Newton-Raphson and secant methods, multi-dimensional optimization, Pareto front, applications in civil engineering. Linear systems: Matrix operations, Eigen vectors and values, Gauss elimination, tri-diagonal systems, LU decomposition, Cholesky factorization, Gauss-Seidel method, iterative methods, applications in civil engineering. Curve fitting: Introduction to statistics, linear least squares regression, polynomial regression, multiple linear regression, non-linear regression, Fourier analysis, discrete Fourier transform, polynomial interpolation (Lagrange, Newton), piecewise interpolation, quadratic, cubic, and spline interpolation, applications in civil engineering. Numerical integration and differentiation: Trapezoidal method, Simpson's method, higher order Newton-Cotes formula, Gauss quadrature, Taylor series approximation, Richardson extrapolation, partial derivatives, applications in civil engineering. Ordinary differential equations: Euler's method, Heun's method, Runge-Kutta method, other multi-step methods, stiff methods, shooting method and finite difference method, applications in civil engineering.

Text Books: Please see references

Reference Books

- Stephen J. Chapman, MATLAB Programming for Engineers (6th Edition), Cengage Learning India Pvt. Ltd, 2019
- Steven C. Chapra, Applied Numerical Methods with Matlab for Engineers and Scientists (4th Edition), McGraw-Hill Education, New York, 2018
- Amos Gilat, and Vish Subramaniam, Numerical Methods for Engineers and Scientists (3rd Edition), John Wiley and Sons, Inc., 2013

Prerequisite: NIL