Course G1462: ENGINEERING COMPUTATION

GENERAL INFORMATION

Fall Semester
6 ECTS credits

INSTRUCTOR(S)

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Description

The main objective of the course is to introduce numerical methods as a fundamental tool for engineering disciplines. We plan to review some main topics of Numerical Algebra (matrix calculations, systems of equations,…) and Numerical Calculus (root finding, interpolation, differentiation and integration, numerical methods for initial and boundary value problems in differential equations,…), with the perspective given by the availability of a computer and working with computational efficiency and controlling the errors . Computer tools and programming will be important; we will use software widely used in engineering and science (MATLAB,,..). We will illustrate and discuss how numerical methods are used in practice, considering examples from Engineering.

TEXTBOOK

"Numerical Methods for Engineers", 6th, 5th editions, Steven C. Chapra and Raymond P. Canale
ISBN: 978-0-07-340106-5, Publisher: McGraw-Hill Book Company, New York, Published 2010, 2005

SYLLABUS

1. Course presentation. Numerical methods and engineering problems. Modeling, approximations, types of errors
2. Taylor series. Application to numerical differentiation. Formulas and errors. Applications
3. Roots of equations. Bracketing: bisection, false position. Open methods: Newton, secant, fixed point
4. Error and convergence in root finding. Newton-Raphson method for solving systems of nonlinear equations
5. Systems of linear equations. Gaussian elimination. Errors and pivoting strategy. Counting operations. Matrix inversion. Matrix factorization : LU, Cholesky, ….
6. Errors in linear systems. Norms, condition number. Iterative methods for linear systems: Jacobi, Gauss-Seidel. Convergence
7. Data fitting: least squares. Engineering examples. Interpolation: divided differences, Lagrange functions. Cubic splines.
8. Numerical Integration. Interpolatory quadrature formulas. Newton-Cotes simple and

composite rules. Errors.

9. High precision quadrature rules: Gaussian quadrature. Domain transformations. Multiple integrals. Monte Carlo methods. Case studies
10. Ordinary differential equations (ODE's). Initial value problems Single step methods: Taylor and Runge-Kutta. Errors.
11. Initial value ODE's: Multistep methods. Predictor corrector. Stiffness. Engineering case studies.
12. Boundary value problems (BVP) in ODE's. Shooting methods. Finite differences. Engineering problems.
13. Basic finite elements for BVP in ODE's. Weighted residuals. Implementation aspects.
14. 2nd order linear partial differential equations (PDE's). Stationary flow: heat, porous media. Finite difference methods.
15. Time dependent problems in PDE's. Parabolic flow. Finite differences schemes: explicit, implicit. Convergence and stability.