Course Number: 28012

Course Name: Advanced Numerical Methods

Course Type: Core	Type & Max Unit: 3 theory
Prerequisite: None	Co-requisite: Advanced Mathematics 1
Level: MSc and PhD	First Presentation:
Group: Energy Conversion	Last Edition: 25 Oct 2017

Objectives:

This course introduces applied numerical methods suitable for solving engineering problems, and compares methods in terms of three important features; accuracy, speed, and robustness. The course especially emphasizes on solving new problems and designing appropriate numerical algorithms when needed.

Topics:

1. Introduction: description of numerical approach in solving engineering problems, introducing basic concepts including convergence, stability, and accuracy.
2. Interpolation and Function Approximation: Use of various approximating functions, minimax principle, Least-square method, interpolating methods with equally-spaced and un-equally-spaced base points, and splines.
3. Numerical Integration: Integration formula using equally-spaced and un-equally-spaced base points, Composite formula, Richardson extrapolation, Romberg method, Adaptive integration, and multiple integrals. Remarks on numerical differentiation.
4. Solution of equations in one variable: methods of solving nonlinear equations, rate of convergence, finding zeros of polynomials.
5. Solving linear system of equations: Review of direct and iterative (stationary and non-stationary) methods, Krylov subspace methods, rate of convergence of methods, and pre-conditioners.
6. Solving nonlinear system of equations: Newton method and quasi-Newton methods, Fixed-point method, Steepest descent method.
7. Solution of Ordinary Differential Equations: Existence and uniqueness of solution, and well-posedness of problem, single-step methods, multi-step methods, prediction-correction methods, error estimation, stability and step-size control, adaptive methods, and solution of boundary value problems.
8. Solution of Partial Differential Equations: classification of PDEs and finite difference methods.

References:

1- Applied Numerical Methods, by B. Carnahan, H.A. Luther and J.O. Wilkes, John Wiley & Sons Inc. 1964.
2- Matrix Computations, G.H. Golub and C.F. Van Loan, Johns Hopkins University Press, Baltimore, 1989. (QA188.G65).
3- Numerical Analysis, R.L. Burden and J.D. Faires, and A.M. Burden, 10th edition, Cengage Learning, 2014. (QA297.B84)
4- Iterative Methods for Sparse Linear Systems, Y. Saad, SIAM, 2003. (**ISBN:** 0898715342)