The George Washington University
Washington, D.C.

MAE 286 – Numerical Solution Techniques in Mechanical and Aerospace Engineering

Fall 2009 – Main Campus

References: *Numerical Solution of Partial Differential Equations: Finite Difference Methods*, third edition, by G.D. Smith (Oxford University Press, 1985), ISBN 0198596502; *The Finite Element Method for Engineers*, fourth ed., by K.H. Huebner, D.L. Dewhirst, D.E. Smith, and T.G. Byrom (Wiley, 2001), ISBN 0471370789.

Notes: *Numerical Solution of Partial Differential Equations* by G.C. Everstine

Instructor: Gordon C. Everstine, `http://gwu.geverstine.com`
gw(at)geverstine(dot)com, 301-977-0936

Schedule: Mondays, Aug. 31 – Dec. 14, 6:10 p.m. – 8:40 p.m.
Mid-Term Exam: Oct. 26
Final Exam: Dec. 14

Description: Development of finite difference and finite element techniques for solving elliptic, parabolic, and hyperbolic partial differential equations. Prerequisite: ApSc 213 or equivalent.

Objectives: To understand the fundamentals of finite difference and finite element solution of partial differential equations of engineering; to increase knowledge of the nature of solutions of equations of different types; to apply the numerical algorithms by solving various equations numerically.

Grading: Assignments 1/3, mid-term exam 1/3, final exam 1/3. All graded work must be completed in accordance with the GW Code of Academic Integrity (`http://www.gwu.edu/~ntegrity/code.html`). Students are encouraged to discuss the meaning of assignments and general approaches and strategies for handling those assignments, but it is not acceptable to share solutions and computer codes.

Course Outline

1. Ordinary differential equations; Euler's method; truncation error; Runge-Kutta methods; systems of equations; boundary value problems; finite differences; shooting methods
2. Classical equations of mathematical physics (Laplace, Poisson, wave, Helmholtz, heat); classification of PDEs; examples; transformation to non-dimensional form
3. Finite difference solution of parabolic equations; explicit and implicit methods; Crank-Nicolson method; stability
4. Finite difference solution of hyperbolic equations; domain of dependence; stability
5. Finite difference solution of elliptic equations; direct and iterative solution; derivative boundary conditions
6. Direct finite element analysis; spring, truss, and beam systems; matrix partitioning and constraints; 2-D continuum problems; change of basis
7. Calculus of variations; the brachistochrone; constraints
8. Variational principles; index notation and summation convention; deriving variational principles; shape functions; compatibility; element matrices; method of weighed residuals (Galerkin's method)
9. Potential fluid flow; symmetry; free surface flows; 2-D wave maker; variational principle; mechanical analogy