Instructor
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Office hours: 10:00am-11:30am TT
Other times by appointment or open-door policy

Schedule
1:30pm-2:45 pm Tuesdays and Thursdays
2010 EB I

Course web page
http://people.engr.ncsu.edu/hluo2/courses/mae766/index.html

Grading Policy

Three computer projects, increasing in scope and complexity as the semester progresses
- Project 1: (20%) 2D Incompressible Finite Element Potential Solver
- Project 2: (20%) 2D Compressible Finite Volume (DG) Euler Solver
- Project 3: (20%) 1D Discontinuous Galerkin Navier-Stokes Solver

Assorted home work (10%)

One mid-term (15%)

Finals Exam (15%)

Due dates for projects to be announced.

Reports must be done in MS word or tex/Latex with equation-generating capability. Reports should be written in the style of a technical paper, with abstract, introduction, description of methodology, results, conclusions, and references sections clearly outlined. Formal, rather than conversational English must be used.

Reports will be graded 60% presentation / explanations / conclusions, 40% numerical results

While you are encouraged to discuss your assignments with your colleagues in the class, under no circumstances should you write your codes in a collaborative manner or collaborate on writing reports, etc. Failure to observe this policy could result in your failing the course.

Programming should be done in FORTRAN or C or C++. If this is a problem, see me.

Choice of computer platform is up to you.

The prerequisite for this course is MAE560, Computational Fluid Mechanics and Heat Transfer. I will also accept MA 584, Numerical Solution of Partial Differential Equations – Finite Difference Methods, or equivalent courses from other institutions. This course assumes familiarity with the governing equations of fluid mechanics,
strong programming skills, linear algebra, and basic numerical methods for solving linear partial differential equations. If you do not have these skills in your background, see me. Failure to have the necessary background could result in an extremely difficult time for you in this course.

MAE 766, Computational Fluid Dynamics
Course Outline

I. Introduction

II. Governing Equations and Discretization / Integration Fundamentals
   1. Compressible Navier-Stokes / Euler equations
   2. Incompressible Navier-Stokes / Euler equations
   3. Potential equations
   4. Cartesian Grids, structured grids, and unstructured grids
   5. Finite difference, finite volume, finite element, and Discontinuous Galerkin methods

III. Numerical solution of the potential equations
   1. Potential equations
   2. Finite element methods
   3. Numerical solution of a linear system
   4. Project 1: Finite-element solution of the potential equations

IV. Numerical solution of the compressible Euler equations
   1. Mathematical properties of the Euler equations
   2. Discontinuous Galerkin (DG) finite element methods
   3. Upwind methods
      1. Upwinding for a scalar equation
      2. Flux-Vector Splitting (FVS) methods
      3. Low-diffusion FVS schemes
      4. Godunov's exact Riemann solver
      5. Roe's approximate Riemann solver
   4. Boundary conditions
   5. Extension to higher-order accuracy: Reconstruction method
   6. Explicit time-stepping methods
   7. Project 2: DG solution of the compressible Euler equations

V. Numerical solution of the compressible Navier-Stokes equations
   1. Discretization of viscous and heat conduction terms
   2. Bassi-Rebay method
   3. Local discontinuous Galerkin method
   4. Inter-cell reconstruction method
   5. Project 3: DG solution of 1D non-linear advection-diffusion equation

Reference books