Draft Syllabus

Computational Fluid Dynamics

AOE 6145, Spring 2013

M-W-F 9:05-9:55am, Randolph Hall Rm. 222 (also offered online)

Course Description: This course offers topics of advanced study in the numerical solution to compressible and incompressible fluid flow problems using finite volume methods.

Prerequesites:

- AOE/ME 4434/5434: Intro CFD (or equivalent)
- AOE 5184: Advanced Aero and Hydrodynamics (or equivalent)
- MATH 3144: Linear Algebra (or equivalent)
- or permission of instructor

Textbook: C. Hirsch, *Numerical Computation of Internal and External Flows*, Vol. 2: Computational Methods for Inviscid and Viscous Flows, John Wiley & Sons, New York, 1988.

Useful References (not required):

J. D. Anderson, *Computational Fluid Dynamics: The Basics with Applications*, McGraw-Hill, 1995 (AOE/ME 5434 Intro. CFD book).

R. H. Pletcher , J. C. Tannehill, and D. A. Anderson, *Computational Fluid Mechanics and Heat Transfer*, 3rd ed., CRC Press, Boca Raton, 2013.

D. D. Knight, *Elements of Numerical Methods for Compressible Flows*, Cambridge University Press, New York, 2006.

J. H. Ferziger and M. Peric, *Computational Methods for Fluid Dynamics*, 3rd Ed., Springer-Verlag, Berlin, 2002.

C. Hirsch, *Numerical Computation of Internal and External Flows*, 2nd Ed. (Vol. 1), Elsevier, 2007.

W.L. Oberkampf and C.J. Roy, *Verification and Validation in Scientific Computing*, Cambridge University Press, Cambridge, 2010.

Instructor: Dr. Chris Roy, Associate Professor, Aerospace and Ocean Engineering Dept.

Prerequisites by Topic: Governing equations for fluid dynamics, partial differential equations, introductory CFD, linear algebra

Topics and Approximate Class Time (~14 Weeks Total):

1. Introduction and review of the basics of CFD (1 wk)
2. Euler equations: focus on 2D/axisymmetric form (1 wk)
3. Discretization approaches: focus on the finite volume method (1 wk)
4. Software engineering and code verification (0.5 wk)
5. Characteristic decomposition of the Euler equations: flux Jacobians, Eigenvalue analysis, similarity transformations, compatibility relations (1.5 wks)
6. Upwind schemes: approaches, second-order methods (κ-schemes), flux limiters, low dissipation schemes (1.5 wks)

7. Temporal integration methods: explicit, implicit, time accuracy (1 wk)
8. Solution verification (0.5 wk)
9. Grid generation (1 wk)
10. Navier-Stokes equations in 2D/axisymmetric form (1 wk)
11. RANS turbulence modeling (1 wk)
12. Incompressible flows (1 wk)
13. Parallel computing via OpenMP and MPI including GPUs (1 wk)
14. CFD applications: ANSYS/Fluent (1 wk)
15. Advanced topics – time permitting (e.g., multigrid methods, unstructured grids, nondeterministic simulations)

Grading:			
	Test 1	15%	
	Test 2	15%	(not cumulative)
	Homework	30%	(includes some programming assignments)
	Project	40%	
	Total	100%	

Project: While a number of smaller programming assignments will be given as part of the homework, an individual project will also be assigned during the semester. The choice of programming language is left up to you. The recommended programming languages are Fortran 95/2003, C, and C^{++}. I do not recommend using MATLAB since it will likely run much slower (factor of 5 at best) than both Fortran and C/C^{++}. A very good Fortran 2003 textbook is: Stephen J. Chapman, *Fortran 95/2003 for Scientists and Engineers*, 3rd Ed., McGraw-Hill, Boston, 2008.

Office Hours: I prefer that you come in during office hours; however, if my office door is open then I am usually free to answer questions.

Dr. Chris Roy, Rm. 330 Randolph Hall, 231-0080, cjroy@vt.edu
Office Hours: TBD

TA: TBD

Test/Exam Policy: All tests and exams will be open notes and open book.

Class Web Page: via Scholar (scholar.vt.edu) called "CFD (Spring 2013)"

Attendance Policy: You are expected to attend all class lectures.

Special Needs: Students who need accommodations are asked to arrange a meeting with me during office hours the first week of classes, or as soon as possible if accommodations are needed immediately. If you have a conflict with my office hours, an alternate time can be arranged. To set up this meeting, please contact me by Email.