Tentative Syllabus for PHYS 695

Applied Fluid Mechanics

Contact Information

- Day(s) and Time: Fri 16:30-19:10
- Location: Exploratory Hall 1004
- Instructor: Rainald Lohner
- Email: rlohner@gmu.edu
- Phone: 703-993-4075
- Office Hour: Thu 10:00-12:00
- Office: Planeteray Hall, Suite 103, Room 103C

Course Description

This new course covers the application of fluid mechanics to current problems in science and industry. Topics to be covered include: a brief introduction to Cartesian tensors; conservation laws of mass, momentum, and energy, and derivation of the Navier-Stokes equations; description of compressible and incompressible flows; introduction to ideal and laminar flows; and an introduction to the basic physical and mathematical foundations of computational fluid dynamics. In addition, numerical methods of finite difference and finite volume schemes are presented to solve the Navier-Stokes equations. Students will be introduced to the art of writing computer codes to solve partial differential equations. An overview of mesh generation methods will be covered: Delaunay method and advancing front method. A series of applications of classic fluid mechanics problems will be introduced. For these real applications, the course will utilize a Computational Fluid Dynamics software package (open source or commercial), demonstrating the entire workflow of a simulation: setup, solution and visualization of flow problems.

Course Prerequisites

PHYS 620 (Continuum Mechanics) or PHYS 705 (Classical Mechanics) or permission of instructor

Course Objectives

- To learn fluid mechanics principles;
- To familiarize students with the derivation of numerical schemes to solve the partial differential equations describing flows, with particular emphasis on finite volume schemes;
- To learn coding, debugging and assess the accuracy of numerical schemes to solve the partial differential equations describing flows;
- To be able to use CFD packages in order to compute and evaluate complex 3-D flows in physics and engineering.

Course Schedule

- Week 1: Introduction to fundamental concepts in fluid mechanics.
- Week 2: Governing Equations: Conservation laws of fluid motion and boundary conditions.
- Week 3: Compressible and incompressible flows. Ideal and laminar flows.
- Week 4: Finite difference method (FDM): heat equation. Tessellating the computational domain.

- Week 5: Finite volume method (FVM): integral formulation, approximation of integrals.
- Week 6: FVM for diffusion problems.
- Week 7: FVM for convection and diffusion problems.
- Week 8: Mid-Term exam.
- Week 9: Solution algorithm for pressure-velocity coupling in steady flows.
- Week 10: FVM for unsteady flows.
- Week 11: Implementation of boundary conditions.
- Week 12: Application-Shallow waters equations.
- Week 13: Application-Renewable energy and fluid mechanics: wind turbines.
- Week 14: Review and discussion.
- Week 15: Final exam.

Textbooks

- P. K. Kundu, I. M. Cohen and D. R. Dowling, *Fluid Mechanics*, 6th Edition, Academic Press, 2015.
- H. K. Versteeg and W Malalasekera, *An Introduction to Computational Fluid Dynamics: The Finite Volume Method*, 2nd Edition, Pearson Education Limited, 2007.

References

- R. Löhner, *Applied CFD Techniques*, 2nd Edition, J. Wiley & Sons, 2008.
- R. J. Leveque, *Finite Volume Methods for Hyperbolic Problems*, Cambridge University Press, 2002.
- G. K. Batchelor, *An Introduction to Fluid Mechanics*, Cambridge University Press, reprinted 2002.
- K. A. Hoffmann and S. T. Chiang, *Computational Fluid Dynamics for Engineers*, Vols. 1 and 2, Engineering Education System, 1993.
- J.C. Tannehill, D. A. Anderson and R. H. Pletcher, *Computational Fluid Mechanics and Heat Transfer*, 2nd Edition, Taylor & Francis, 1997.
- C. Hirsch, *Numerical Computation of Internal and External Flows*, Vols. 1 and 2, Wiley, 1988.

Grading

- Homework/Project: 40%
- Midterm: 20%
- Final Exam: 40%
- Course grade will be a letter grade. The following graduate grading is available at university catalog.

Grade	Quality Points	Graduate Courses
A+	4.00	Satisfactory/Passing
A-	4.00	Satisfactory/Passing
A	3.67	Satisfactory/Passing
B+	3.33	Satisfactory/Passing
B	3.00	Satisfactory/Passing
B-	2.67	Satisfactory/Passing
C	2.00	Unsatisfactory/Passing
F	0.00	Unsatisfactory/Failing

Academic Integrity
All students will be expected to abide by the Honor Code: Student members of the George Mason University community pledge not to cheat, plagiarize, steal, or lie in matters related to academic work.

University Policy
University Policies: http://universitypolicy.gmu.edu/

Disability Accommodations
If you have a learning disability or other condition that may affect academic performance, please:
a) Make sure documentation is on file with Office of Disability Services (SUB I, Rm. 4205; 993-2474; http://ods.gmu.edu) to determine the accommodations you need; and
b) Talk with the instructor to discuss your accommodation needs.