Department of Civil and Environmental Engineering

CIVE 607 - Computational Fluid Dynamics (Spring 2014)

Instructor
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Office hours: MW 1.30-2.30 PM
in A207E – Engr. Building, or
by appointment.

Lectures: MWF 12.00 -12.50 PM, E202 (Engineering)

Class website: https://ramct.colostate.edu/

Textbook: Class will be taught using lecture notes prepared by instructor. However, the main supplementary text book to get is An Introduction to Computational Fluid Dynamics: The Finite Volume Method" by H. K. Versteeg and W Malalasekera, Pearson/Prentice Hall.

Some useful reference textbooks that maybe available in the library include:
- Computational Fluid Dynamics –The Basics with Applications by John D. Anderson, McGraw Hill, 1995.
- Computational Methods for Fluid Dynamics by Joel H. Ferziger and Milan Peric, Springer Verlag, 1999.
- Computational Fluid Dynamics – Applications in Environmental Hydraulics by Paul D. Bates, Stuart N. Lane and Robert I. Ferguson, John Wiley and Sons, 2005.
- Fluid Mechanics by Pijush K. Kundu and Ira M. Cohen, Academic Press, 2004.
- Computational Techniques for Fluid Dynamics, Vol. 1 & 2 by Clive A. Fletcher, Springer, 1991.
- Fundamentals of Computational Fluid Dynamics by Patrick J. Roache, Hermosa, 1998.
- Chen, Ching-Jen and Jaw, Sheng-Yuh, Fundamentals of Turbulence Modeling, 1997, Taylor & Francis

Course Prerequisite: CIVE 300 – Fluid Mechanics and a numerical modeling course (e.g. ENGR550).

Overview: This first course will focus on providing an in-depth introduction to numerical methods used in computational solutions of fluid mechanics, hydraulic and wind engineering problems. Course topics include: Introduction to turbulence models and to basic concepts of numerical simulation and computer modeling of turbulent flows in the environment. Applications of numerical models in hydraulics, environmental fluid mechanics and wind engineering will be explored. Use of commercial codes such as

Fluent and FLOW3D etc. for river, estuarine and wind engineering problems will be discussed.

Course Objectives: The thrust of this CFD course is to enable students to apply numerical techniques and analysis to solve fluid dynamics problems of interest in hydraulics and wind engineering. Successful students will be able to:
- Describe the importance of each term in the governing fluid flow and transport equations.
- Demonstrate a basic understanding of turbulence modeling for hydraulic, environmental and wind engineering flows.
- Develop the discretized forms of the governing equations using the finite-difference and finite-volume approaches.
- Carry out numerical stability and error analysis of different numerical schemes used in CFD.
- Design algorithms for solving some basic partial differential equations (PDEs).
- Write basic computer code to solve simplified forms of the governing equations.
- Critically review CFD methods proposed in literature.
- Identify and use suitable commercial CFD codes to solve practical problems of interest.

You should also expect to:
- Take responsibility for your learning
  - Read textbooks/journal papers on your own
  - Ask questions from me, your classmates and yourself
  - Turn in excellent assignments demonstrating your knowledge of the solution
- Tap into your existing intuition, strengths, and passion to learn fluid dynamics
- Become an active participant in your computational fluid dynamics education, taking full advantage of lectures, texts, homework, office hours and everyday life!

COURSE LOGISTICS

Course website: https://ramct.colostate.edu/ The RamCT website will be used to post homework assignments and solutions, practice exams, lecture notes, announcements etc. You can also check your grades online.

Computing: Homework assignments will include problems that require programming using Matlab (or any other basic programming language such as FORTRAN or C that you are familiar with). You can access Matlab on the Engineering servers easily or better still, get your own student copy from the software store on campus! A tutorial can be found at the following website:
http://www.mathworks.com/academia/student_center/tutorials/intropage.html)

Homework: Assignments will be posted weekly or bi-weekly (depending on the extent of work involved) on the RamCT class webpage. Please note that reading assignments may be examined via pop-up quizzes. **Home works are due by the end of class every**

Friday. **No late homework assignments will be accepted except for legitimate reasons acceptable to the instructor**. While you are encouraged to discuss assignments with each other, you may not look or copy anyone else's written work.

Your solution to homework problems should:
- Formulate/define the problem
- Indicate the solution procedure clearly
- Draw your conclusions by highlighting the answers with correct units!
- Must be submitted using Engineering paper or letter size white paper.
- All homework submissions should be stapled, with **Computational Fluid Dynamics CIVE607– Spring 14, Assignment No., Name and CSUID** written on top of first page. Please write your name on top of all other pages in case bindings get loose.

You are expected to arrange your work in a neat and orderly manner. This will not only help others to understand your work but will aid your thought process.

Exams: There will be one midterm exam and a final project. Material in the exams will be drawn from lectures and homework assignments. Collaboration or copying from others during an exam will not be tolerated and may result in zero credit and referral to Student Conduct Services. All exams are closed book. However, I will allow each student to bring in one single-sided letter size paper with his/her handwritten notes and formulae. No other resources will be allowed during the exams.

Course Evaluation: Students will be evaluated as follows:
- Weekly/Bi-weekly homework assignments focusing on basic methods, numerical discretization, error analysis, programming exercises and application- 40%
- Quizzes, other assignments & attendance - 5%
- Midterm examination - 25%
- A final team project (preferably individual projects given the size of the class though students may work in teams of two with the consent of the instructor) – 30%

Term grades for this course will use the +/- grading system as described in the CSU catalog. Grading will be assigned according to a traditional grade scale at a minimum, i.e. A=90-100%, B=80-89%, C=70-79%, D=60-69, F <60%.

Makeup exam policy: For folks who can not attend regular exams due to university business duty, serious illness, or family emergency (all with written proof or statement), a makeup exam may be arranged AFTER the regular exam. Please inform the instructor as soon as possible. No exceptions will be made without a legitimate reason and a timely arrangement. There are no make-ups for pop-up quizzes.

Academic Integrity: Academic dishonesty is a serious issue. University rules including academic penalty and further investigation by the university authorities will be strictly enforced in this course. *Please note that this course will adhere to the Academic Integrity*

Policy of the Colorado State University General Catalog (Page 7) and the Student Conduct Code." Please review these documents for details regarding these rules. Also, the honor pledge system will be used in this course. The following honor pledge (not compulsory) shall be included in all exams and assignments in this course:

I pledge on my honor that I have not received or given any unauthorized assistance in this exam (replace with assignment as required), **followed by your signature.**

How to survive and thrive in this course: Find a study group! Take advantage of office hours! If you have a question, ask it. Enjoy the subject and its numerous applications in engineering and the natural environment!

<u>TENTATIVE COURSE SCHEDULE:</u>
Jan. 22   First lecture
April 7   Midterm Exam
May 5 & May 7 & May 9 - Final Project presentations
May 12   Final Exam **4.10-6.10 pm**!

Week	Topics
1 - Jan. 20	Introduction, Governing Equations for Fluid Flow, Overview of Relevant Physical cases, Non-dimensionalization
2 - Jan. 27	Discretization Techniques – Power Series, Taylor Series, Differencing Derivatives
3 – Feb. 3	Time Marching Schemes
4 – Feb. 10	Numerically Induced Physics and Stability Analyses (Von Neumann and Hirt Methods)
5 – Feb. 17	Transport Modeling – Advection Equation
6 – Feb. 24	Transport Modeling – Advection-Diffusion Equation
7 – Mar. 3	Saint Venant Equations – Linear methods
8 - Mar. 10	Saint Venant Equations – Nonlinear methods,
9 – Mar. 17	**SPRING BREAK – NO CLASSES**
10 – Mar. 24	Essence of Turbulence Modeling – Introduction, 1-D
11 – Mar. 31	Essence of turbulence modeling – Introduction to Two-Equation Models e.g. k-ε model, k-ω model, Mellor-Yamada model etc - models
12 - April 7	Primitive Hydrostatic Equations **Midterm Evening Exam April 7th (Monday)**
13 - April 14	Grid Generation, Invited Lecture.
14 - April 21	Applications - River Flows, Floodplain Flows, Sediment Transport Modeling and Invited Lecture
15 - April 28	Applications – Estuarine Flows, Water Quality, Flow through Vegetation, Dispersion Modeling, and Invited Lecture
16 – May 5	**Final Project Presentations**, summary and future directions
May 12	**Final Exam – 4.10-6.10 pm**