

# **Syllabus**

## **Numerical Fluid Dynamics (*PHYS 8750*)**

**9:30 am – 10:45 am, TR**  
**Fall 2020**

### **Instructor**

Prof. Xian Lu  
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### **Office Hours**

TR 10:45 am – 11:45 am; or by appointments.

### **Prerequisite**

1. MATH 1070; 2080; 8260; PHYS 2210; 3150; 4200 Or equivalent courses from other disciplines. Please talk to the instructor for more advices.
2. Programming skills in Fortran, MATAB, IDL or Python.

### **Textbooks:**

#### **Required**

Durrant, D. R., *Numerical Methods for Fluid Dynamics with Applications to Geophysics*, 2nd ed., 516 pp., by Springer, New York, 2010.

#### **Optional**

Ferziger, J., and M. Peric, *Computational Methods for Fluid Dynamics*, Third Edition, Springer, 2001.

J.Tu, G.Yeoh, and C. Liu, *Computational Fluid Dynamics: A Practical Approach*, 2007.

Kundu, P., I. Cohen, and D. Dowling, *Fluid Mechanics (5th edition)*, 2011.

Mark, Z. J., *Fundamentals of Atmospheric Modeling*, Cambridge University Press, 1999.

### **Course Outline**

This is a graduate-level course which introduces the graduate and advanced undergraduate students to finite difference methods as a means of solving different type of differential equations that arise in fluid dynamics; basic properties of computational methods – accuracy, stability, consistency, convergence, and etc; finite element and finite volume methods; and error control and stability considerations. This course highlights different numerical schemes for prototype dynamic equations, such as transport (advection), diffusion, and wave equations. It analyzes the advantages and drawbacks of each numerical method to numerically solve these equations. It also introduces sophisticated atmospheric and space weather models. Students will make their own codes to prove what they learn from the class. They will also learn how to run the models on Clemson's Palmetto supercomputer. This course aims to improve students' fundamental understanding of fluid dynamics, and the ability to judge and select finite difference schemes for differential equations. The students will also be exposed to Linux working environment and commands and familiarize themselves with supercomputing. This course will train students' programming skills, graphic

plotting and demonstration, independent and critical thinking, and problem-solving and communication skills.

## **Learning Outcomes**

1. Make students familiar with the primitive equations controlling fluid dynamics such as transport (advection), diffusion, and wave equations.
2. Introduce the fundamental and widely-used numerical difference schemes and apply these schemes to fluid dynamics equations.
3. Mentor students to develop and code their models and introduce the advantages and disadvantages of various types of numerical methods used in the difference schemes.
4. Familiarize students with supercomputing, linux working environment, and job scripts.
5. Enhance students' understanding of the fluid dynamics and numerical modeling by analyzing the results from the models they developed or modified and the related results.

## **Exams**

There will be one mid-term exam. There will be no final exam. Instead, a final project is assigned.

## **Homework**

Homework is designed to answer the theoretical questions of the numerical modeling and difference schemes. Students are expected to gain a deeper understanding and a broader perspective of the subject. Homework is due on the date assigned. Late homework will not be accepted.

## **Computing Problems and Final Projects**

Computing problems and final project focus on programming, code modification and implementation, and the ability to apply modeling tools to understand and appreciate fluid dynamics. Students are expected to work independently on their own coding and present their results in publishable graphics. Students will choose a certain topic to work on for the final project.

## **Course Grades and Weights**

- 30% Homework
- 30% Computing Problems
- 20% Mid-term
- 20% Final Project

A: 85-100; B: 70-85; C: 55-70; D: 40-55; F: 0-40

## **Attendance Policy**

Attendance is required for all classes. You are responsible for any materials covered in the lectures and any announcements made during the classes. This also applies to arriving late to class or leaving early. If the instructor is late for class, students are expected to wait for 15 minutes before

they leave. Also see the general statement on attendance in the Undergraduate Announcements.

### **Online Classes**

This course will be mainly online live lectures. Zoom and other online teaching tools will be used to make the teaching interactive and as most efficient as possible. Students will be provided with the access to the Palmetto supercluster and run codes there.

### **Class Web Page**

The course web site, announcements, assignments, instructional material, etc. can be accessed via Canvas.

### **Academic Integrity Policy**

As members of the Clemson University community, we have inherited Thomas Green Clemson's vision of this institution as a "high seminary of learning." Fundamental to this vision is a mutual commitment to truthfulness, honor, and responsibility, without which we cannot earn the trust and respect of others. Furthermore, we recognize that academic dishonesty detracts from the value of a Clemson degree. Therefore, we shall not tolerate lying, cheating, or stealing in any form.

### **Disability Access Statement**

Clemson University values the diversity of our student body as a strength and a critical component of our dynamic community. Students with disabilities or temporary injuries/conditions may require accommodations due to barriers in the structure of facilities, course design, technology used for curricular purposes, or other campus resources. Students who experience a barrier to full access to this class should let the professor know, and make an appointment to meet with a staff member in Student Accessibility Services as soon as possible. You can make an appointment by calling 864-656-6848, by emailing [studentaccess@lists.clemson.edu](mailto:studentaccess@lists.clemson.edu), or by visiting Suite 239 in the Academic Success Center building. Appointments are strongly encouraged – drop-ins will be seen if at all possible, but there could be a significant wait due to scheduled appointments. Students who receive Academic Access Letters are strongly encouraged to request, obtain and present these to their professors as early in the semester as possible so that accommodations can be made in a timely manner. It is the student's responsibility to follow this process each semester. You can access further information here: <http://www.clemson.edu/campus-life/campus-services/sds/>.

### **Title IX Statement**

Clemson University is committed to a policy of equal opportunity for all persons and does not discriminate on the basis of race, color, religion, sex, sexual orientation, gender, pregnancy, national origin, age, disability, veteran's status, genetic information or protected activity in employment, educational programs and activities, admissions and financial aid. This includes a prohibition against sexual harassment and sexual violence as mandated by Title IX of the Education Amendments of 1972. This policy is located at <http://www.clemson.edu/campus-life/campus-services/access/title-ix/>. Mr. Jerry Knighton is the Clemson University Title IX Coordinator. He also is the Director of Access and Equity. His office is located at 110 Holtzendorff Hall, 864.656.3184 (voice) or 864.656.0899 (TDD).

