Astrophysical Fluid Dynamics Syllabus

Astrophysical Fluid Dynamics
Special Topics course PHYS 390/590:
Spring 2023
Explanatory Hall L111, Tuesday 4:30-7:10 pm

1. **Catalog description:** This is an interdisciplinary introduction to the theory of fluid dynamics for astrophysicists, physicists, and space scientists. The focus is on the physical and mathematical understanding of the governing equations of fluid mechanics and how they help us better understand the physical processes in the universe.

2. **Introduction:** This is an interdisciplinary course covering the fluid dynamics of geophysical and astrophysical fluids.

3. **Instructor and contact information**
   a. Erdal Yiğit, Planetary Hall 261,
      https://sites.google.com/view/erdalyigit/
      eyigit@gmu.edu
   b. Office Hours: Thu, 1-2pm, Planetary Hall 261

4. **Course website:**
   https://sites.google.com/view/erdalyigit/teaching/astrophysical-fluid-dynamics

5. **Specific course goals**
   a. Learn the fundamentals of fluid dynamics

6. **Course formats and activities**
   a. Weekly Lectures
   b. Weekly homeworks
   c. In-class discussions

7. **Outline/Course — Tentative and booked slots**
   a. Fluids in the universe
   b. Mathematical preliminaries
   c. Fluid properties

    c.   In-class discussions

7. Outline/Course plan Tentative weekly schedule
   a. **Fluids in the universe**
   b. Mathematical preliminaries
   c. Fluid properties
   d. Basic conservations laws and equations of fluid dynamics
   e. Thermodynamics of fluids
   f. Transport processes
   g. Turbulence
   h. Waves
   i. Instabilities
   j. Chaos
   k. Modeling of fluid phenomena (My ch 9)
   l. Applications of fluid dynamics to space physics and astrophysics

8. **Recommended Textbooks**
   The lecture notes will be <u>self-contained</u>, but the following books could be helpful:
   - Clarke and Carswell, 2007, Principles of astrophysical fluid dynamics
   - Batchelor, 1967, Introduction to fluid dynamics
   - Paterson, 1984, A first course in fluid dynamics
   - Landau and Lifshitz, Fluid Mechanics,

   Other books are:
   - Kato, Fundamentals of astrophysical fluid dynamics
   - Strogatz, Nonlinear dynamics and chaos
   - Faber 1995, Fluid dynamics for physicists
   - Sears, 2011, theoretical aerodynamics and hydrodynamics
   - Kundu and Cohen 2002, Fluid Mechanics
   - Guyon, 2001, Physical hydrodynamics

9. **Course policy and grading**
   a. Grading distribution
      i. Undergraduate and graduate grading
         □ Exam 30%,
         □ Term paper 30%,
         □ Homeworks 40%
      ii. Numerical grade ranges
         https://catalog.gmu.edu/policies/academic/grading/
         1) Graduate:
            100-95% (A+), 95-90% (A), 90-85% (A-), 85-80% (B+), 80-75%

         2) Undergraduate

1) Graduate:

100-95% (A+), 95-90% (A), 90-85% (A-), 85-80% (B+), 80-75% (B), 75-70% (B-),70-60% (C), < 60% (F)

2) Undergraduate
100-95% (A+), 95-90% (A), 90-85% (A-), 85-80% (B+), 80-75% (B), 75-70% (B-), 70-65% (C+), 65-60% (C), 60-55% (C-), 55-50% (D), < 50% (F),

   iii.   Tentative exam schedule
2nd May 2023 (1-hour short exam).

10. **<u>Homeworks</u>** will include problems related to topics covered in the lecture. In every assignment, 5% of your grade will be based on the following criteria:

   a.   Write clearly and provide understandable and well organized solutions

   b.   Number each page; clearly indicate which problem you are working on; start each problem solution on a new page.

   c.   Incorporate additional guidelines and suggestions discussed in the lecture.

   d.   Add some (brief) explanations in your derivations and problem solutions so that it is clear what your solution path is.

   e.   Staple your sheets in the right order.

Successful solution of all problems will give you 95%. To get 100% you need solve all the problems and fulfill all the criteria above (+5%) in your submission. Depending on the performance and issues that can arise, this list may be updated during the semester.

Note that lack of clarity and organization in a given problem solution or derivation will lead to point subtractions even if the final solution is correct.

All HW assignments can be found on the course website. HW solutions are to be submitted by the beginning of class.

You can type your solutions using latex, word, or any other equation editor, or simply submit handwritten solutions, following (a)-(e) above.

10% will be subtracted for each late day of submission.

11. **Term paper**

simply submit handwritten solutions, following (a)-(e) above.

11. **Term paper**
    a. Terms papers are due by the beginning of the last lecture of the semester 2nd May 2023
    b. Term paper presentation (15 minutes)
        i. 2nd May 2023
    c. Suggested topics
        i. Planetary atmospheres
        ii. Fluid dynamics of planets
        iii. Remote sensing
        iv. Modeling of fluids dynamics
        v. Buoyancy waves
        vi. Accretion disks, etc.
        vii. Habitability and fluid dynamics

    d. Format:
        i. **Abstract:** A brief description of the paper, not to exceed 200 words.
        ii. **Introduction:** This section describes the the histocal background and context of the topic, citing the appropriate papers. Recent investigations related to the topic are summarized and the goals of the paper are clearly stated along with a brief statement of the main methodology of the research.
        iii. **Main part:** This part presents the main results of the investigation, putting the results in the context of published work.
        iv. **Summary and Conclusions:** Main results and conclusions of the paper are summarized.
        v. **References:** List of cited work (American Geophysical Union style is recommended).
        vi. **Specific Format of the term paper:** The paper must be typed, double-spaced, about 15–20 pages long (excluding figures), and have at least 4 figures with captions. All pages must be numbered. Use "Times" with 12pt script size. Section titles should be bold.

12. **Academic integrity :**
    GMU is an Honor Code university; please see the University Catalog for a full description of the code and the honor committee process. The principle of academic integrity is taken very seriously and violations are treated gravely.

description of the code and the honor committee process. The principle of academic integrity is taken very seriously and violations are treated gravely. Academic integrity essentially means when you are responsible for a task, you will perform that task yourself. When you rely on someone else's work in an aspect of the performance of that task, you will give full credit in the proper, accepted form.

In particular, when you are writing a paper, you must give credit to the works/sources that you have used directly.

Furthermore, extensive amount of discussion and debate are encouraged in this course, with the firm expectation that all aspects of the class activities will be performed with great respect toward differing ideas, perspectives, and traditions. The students are encouraged to seek guidance when they are in doubt (of any kind).

13.   **Students with disability**

If you are a student with a disability and you need academic accommodations, please see me and contact the Office of Disability Resources at 703/993-2474 All academic accommodations must be arranged through that office.

14.   **General Guidelines**

You should participate in all lectures and take your own notes. Listening to the lectures and participating in discussions will help you a lot.

For exam preparation, you should review your lecture notes, consider discussions during the lectures, and study your problem sheets extensively.