Physics 784 – Advanced Magnetohydrodynamic Theory

CLASS DETAILS:
• Meeting Times: MW, 12:30-1:45pm Rm G51 White Hall
• Course Web Site: http://ulysses.phys.wvu.edu/~pcassak/phys784.html
• Instructor: Dr. Paul Cassak Rm 333 White Hall
• Contact Info: pacassak@mix.wvu.edu (304) 293-5102

OFFICE HOURS:
• In Room 333 of White Hall unless announced otherwise.
• Set times - Tuesday 1:30-2:30pm + by appointment + whenever the door is open
• Please come by for help with concepts, homework, or other advice!

PREREQUISITES:
• Catalog says – Physics 781 (Principles of Plasma Physics), Physics 631 (Classical Mechanics) and Physics 634 (Electromagnetism)

COURSE OBJECTIVES:
This course is an advanced survey of fluid theory of plasmas at a graduate level. The objective of this course is to develop a deep understanding of concepts and analytical techniques of fluid theory used in plasma physics. The goals include evaluating when fluid theory is appropriate and applying it to laboratory and space/astrophysical systems.
• The topics to be covered are: (from the graduate catalog) the fluid approximation, magnetohydrodynamic description of plasma equilibrium and stability, confinement schemes and plasma waves (emphasis on analytic theory)
There is no way to cover everything in fluid theory in a single semester, and it is not the goal of this course to do so. The goal is to build a foundation and expose you to examples of its uses, which will allow you to learn whatever application interests you.

EXPECTED LEARNING OUTCOMES:
Upon successful completion of this course, you will have:
1) developed an understanding of fluid plasmas both mathematically and physically.
2) developed an ability to use scaling arguments to qualitatively evaluate systems.
3) learned when applying fluid theory is appropriate.
4) learned techniques to analyze laboratory and space/astrophysical systems.

TEXTBOOK:
The Physics of Fluids and Plasmas, An Introduction for Astrophysicists
by Arnab Rai Choudhuri

OTHER BOOKS OF INTEREST:
• Introduction to Plasma Physics, R. J. Goldston and P. H. Rutherford **GOOD**
• The Physics of Plasmas, R. Fitzpatrick
  http://farside.ph.utexas.edu/teaching/plasma/plasma.html **FREE**
• Plasma Physics for Astrophysics, Russell M. Kulsrud **CHEAP**
• Principles of Magnetohydrodynamics, J. P. Goedbloed and Stefaan Poedts
• Introduction to Magnetohydrodynamics, P. A. Davidson *ENG. PERSPECTIVE*
SUPPLEMENTARY MATERIALS:

In addition to the Choudhuri textbook, additional resources may be provided. Possible sources include (but are not limited to) the following:

• Fluid Mechanics by Pijush K. Kundu
• Lecture Notes by Adil Hassam at University of Maryland
• Ideal magnetohydrodynamics by Jeffrey P. Freidberg
• Plasma Physics for Astrophysics, by Russell Kulsrud
• Physics of the solar corona by Markus Aschwanden
• Lecture Notes by Barrett Rogers at Dartmouth College
• Introduction to space physics by Margaret G. Kivelson and Christopher T. Russell

CLASS EXPECTATIONS:

• Your focus should be on physical understanding, not rote memorization.
• It is expected that you will put forth an active effort into learning.
• It is expected that you will do the reading before class.
• This course should be treated as “guided independent study.” Do not expect that attendance is sufficient or lectures are complete. Important topics will be left out!
• We will do some active learning techniques - please be willing to try them.
• It is expected that you will be considerate of your fellow classmates and myself – I will turn my cell phone ringer off, too.

SCHEDULING:

There will be no class on March 17 and 19 because I will be at a conference. Make-up classes will be scheduled according to availability, likely Fridays at the end of April.

HOMEWORK:

• Homework is assigned approximately every week and a half and is intended to challenge you beyond mere regurgitation. Problems are not chosen randomly – they cover topics we don’t have time to cover in class or real world applications!
• If you’re stuck on homework, talk to your classmates or come see me for help!

ASSESSMENTS:

There will be two assessments, which will either be exams or written projects. The format will be decided as the semester progresses depending on student engagement. If exams, the midterm would be a take-home exam given out on March 5 and due on March 24. The final would be cumulative and performed in class (on April 28 at 11am). If written projects, you will summarize a journal article on a topic related to classroom topics. This should be in your own words and shouldn’t need to be more than 2-4 pages. The first, due March 24, would be chosen from a list provided by me. The second, due April 28 and presented orally as well, would be chosen by you.

COLLABORATION POLICY:

Science is fundamentally a collaborative endeavor. It is very rare in the modern world for someone to sit alone in a room and make important contributions to science. As such, working together on homework is encouraged! However, an important balance must be reached. Copying someone else’s solution is not allowed in science, nor will it be allowed in this class. An appropriate technique is to try the homework on your own first, then discuss it with your classmates, then try again on your own.
GRADING BREAKDOWN AND SCHEME:
Your grade will be based on homework (50%), the mid-term assessment (15%), the final assessment (20%) and class participation (15%). There will be approximately 8 assignments, as shown on the schedule. Homework grading will be weighted to make more time consuming assignments worth more. Grades will be awarded roughly as:

<table>
<thead>
<tr>
<th>Grade</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>100-90%</td>
</tr>
<tr>
<td>B</td>
<td>90-80%</td>
</tr>
<tr>
<td>C</td>
<td>80-70%</td>
</tr>
<tr>
<td>D</td>
<td>70-60%</td>
</tr>
</tbody>
</table>

Some regard will be paid to natural breaks in the grade distribution. I reserve the right to adjust grade scales (i.e., curve) in the interest of fairness and propriety if warranted.

GRADING POLICIES:
• Homework is due at the beginning of class. Homework turned in up to a week late will be graded by the same standards as on-time homework, but there is a penalty for lateness of 50%.
  ○ If you don’t finish on time, submit what you have and turn the rest in late!
• Partial credit is awarded, so develop your ideas logically. Show your work (credit is for the process, not the solution!) and draw sketches where appropriate.
• Take pride in your work. If your solution is illegible, I can’t give credit.
• Grading appeals must be made within one week of when the submission is returned.

SOCIAL JUSTICE STATEMENT:
WVU policy – “West Virginia University is committed to social justice. I concur with that commitment and expect to maintain a positive learning environment based upon open communication, mutual respect, and nondiscrimination. Our University does not discriminate on the basis of race, sex, age, disability, veteran status, religion, sexual orientation, color or national origin. Any suggestions as to how to further such a positive and open environment in this class will be appreciated and given serious consideration.

“If you are a person with a disability and anticipate needing any type of accommodation in order to participate in this class, please advise me and make appropriate arrangements with Disability Services (304-293-6700).” The University has many programs in place. Please let me know if I can be of any assistance, and do so with sufficient notice.

ACADEMIC INTEGRITY STATEMENT:
WVU policy – “The integrity of the classes offered by any academic institution solidifies the foundation of its mission and cannot be sacrificed to expediency, ignorance, or blatant fraud. Therefore, I will enforce rigorous standards of academic integrity in all aspects and assignments of this course. For the detailed policy of West Virginia University regarding the definitions of acts considered to fall under academic dishonesty and possible ensuing sanctions, please see the Student Conduct Code at http://www.arc.wvu.edu/admissions/integrity.html. Should you have any questions about possibly improper research citations or references, or any other activity that may be interpreted as an attempt at academic dishonesty, please see me before the assignment is due to discuss the matter.”