PHYS:7730 Final Project

A brief description of your final project topic is due at the beginning of class, Thursday, March 24, 2022.

An Annotated Bibliography is due at the beginning of class, Thursday, April 14, 2022.

Your final project is due at the beginning of class, Thursday, May 5, 2022.

The final project for PHYS:7730 Advanced Plasma Physics is your opportunity to extend your knowledge of the plasma physics of one particular advanced topic.

Format In order to allow you significant latitude to pursue the topic of your greatest interest, the final project may take one of three possible formats:

1. A "course lecture" on a new topic, or extension of a topic we have covered, consisting of a set of lecture notes similar to those that I hand out at the beginning of each lecture. (Note that you do not have to give the lecture.)
2. A detailed calculation of a particular mathematical problem arising from the study of advanced plasma physics. For example, a calculation of the resistive tearing instability (see GB17, Sec 7.5).
3. A literature review of the present state of knowledge on a particular topic, for example, what is presently known about structure of quasiparallel or quasiperpendicular collisionless shocks.

For any of these project formats, the length of the final project should be approximately 5 to 10 pages. The project may be handwritten or typed. If it is handwritten, please be sure that the presentation is sufficiently polished and that the writing is legible.

Potential Topics A list of possible topics for a final project is below, but please feel free to devise a topic of your own interest that does not appear on this list. Also, don't hesitate to consult with me if you are unsure of what topic you would like to tackle and would like some further advice.

1. Review of theories of proposed mechanisms for the dissipation of plasma turbulence.
2. Review of numerical evidence for the mechanisms of dissipation of plasma turbulence
3. Review of observational or experimental evidence for the mechanisms of dissipation of plasma turbulence
4. Derivation of the field-particle correlation technique for the identification of particle energization mechanisms in kinetic plasmas and the quanitification of the rates of energization
5. Classification of discontinuities and shocks in an MHD plasma
6. The detailed kinetic physics of quasiperpendicular collisionless shocks
7. The detailed kinetic physics of quasiparallel collisionless shocks
8. A Review of Particle Acceleration Mechanisms at Collisionless Shocks
9. Calculation of the linear resistive tearing instability (related to magnetic reconnection)
10. The Plasmoid Instability in Magnetic Reconnection
11. A single-particle-motion description of magnetic reconnection
12. Differences in the physics of magnetic reconnection between a resistive MHD plasma and a collisionless plasma

13. The Physics of Bremsstrahlung Radiation
14. The Physics of Synchrotron Radiation
15. The Physics of Compton Scattering
16. The Parker Solar Wind Solution
17. MHD plasma waves in an inhomogeneous plasma
18. Faraday rotation of electromagnetic radiation
19. The Resistive Kink Instability
20. The Kelvin-Helmhotz Instability
21. Magneto-Thermal Instability
22. Heat Flux Buoyancy Instability
23. The Magnetorotational Instability
24. The Parker Magnetic Buoyancy Instability
25. The Firehose Instability
26. The Mirror Instability
27. The Ion Cyclotron Instability
28. The Weibel Instability
29. Kinematic Dynamo Theory
30. The Physics of Drift Waves
31. The Physics of Transit-Time Damping
32. The Physics of Alfvén Wave Collisions

References In addition to our recommended textbooks (Gurnett & Bhattacharjee 2017, Boyd & Sanderson 2003 *The Physics of Plasmas*, 2003 and Bellan 2006) here are some useful general references for identifying interesting final project topics:

1. Margaret G. Kivelson & Christopher T. Russell, *Introduction to Space Physics*, Cambridge, 1995.
2. Toshiki Tajima & Kazunari Shibata, *Plasma Astrophysics*, Perseus, 2002.
3. F. H. Shu, *The Physics of Astrophysics, Volume I: Radiation*, University Science Books: Mill Valley, CA 1991.
4. F. H. Shu, *The Physics of Astrophysics, Volume II: Gas Dynamics*, University Science Books: Mill Valley, CA 1992.
5. Gombosi, *Physics of the Space Environment*, Cambridge University Press: Cambridge, 1998.
6. Baumjohann & Treumann, *Basic Space Plasma Physics*, Imperial College Press: London, 1997.
7. Treumann & Baumjohann, *Advanced Space Plasma Physics*, Imperial College Press: London, 1997.
8. Kulsrud, *Plasma Physics for Astrophysics*, Princeton University Press: Princeton, 2005.
9. D. Biskamp, *Magnetic Reconnection in Plasmas*, Cambridge University Press, 2000.

10. D. Burgess & M. Scholer, *Collisionless Shocks in Space Plasmas*, Cambridge University Press, 2015.

11. A. Balogh & R. A. Treumann, *Physics of Collisionless Shocks*, Springer, 2013.

12. G. B. Rybicki & A. P. Lightman, *Radiative Processes in Astrophysics*, Wiley, 2004.

13. N.A. Krall & A.W. Trivelpiece, *Principles of Plasma Physics*, McGraw-Hill Kogakusha, 1973.

14. Schrijver & Siscoe, *Heliophysics: Plasma Physics of the Local Cosmos*, Cambridge University Press: Cambridge, 2009.

15. Schrijver & Siscoe, *Heliophysics: Space Storms and Radiation: Causes and Effects*, Cambridge University Press: Cambridge, 2009.

16. Schrijver & Siscoe, *Heliophysics: Evolving Solar Activity and the Climate of Space and Earth*, Cambridge University Press: Cambridge, 2009.

A longer list of references is available on the course website:
`https://homepage.physics.uiowa.edu/~ghowes/teach/phys7730/references.html`

Deadlines

1. Thursday, March 24, 2022: Please turn in a sheet stating the topic you have chosen for your project, with a few sentences describing your intended treatment of the topic, and your choice of format (lecture, calculation, or review).

2. Thursday, April 14, 2022: Please turn in an Annotated Bibliography of references that you will use as source material for your final project. For projects in the course lecture or detailed calculation formats, the bibliography must include a minimum of 5 items. For a project in the literature review format, the bibliography must include a minimum of 10 items.
   Note that your final project is not limited to the references submitted for this assignment.

3. Thursday, May 5, 2022: Your completed final project, approximately 5 to 10 pages, must be turned in before the beginning of our final class meeting.