

Syllabus for ENU6937/4930

Conceptual Plasma Physics and Thermonuclear Reactions

Catalog Description (3 Credits) –

1. This course introduces the basic concepts of plasma physics, particularly as related to the science of thermonuclear fusion. Of specific interest is the Ignition Challenge that is central to recent research in inertial confinement and magnetic confinement fusion. Inertial fusion will segue into the topic of high energy-density physics. Generally, the subject of plasma physics has developed a mystique, resulting in a perception of being too complex and impenetrable. The primary intention of this course is to dismantle that notion. ENU 6937/Section 6010; ENU 4930/Section 5486.
2. **Pre-requisites and Co-requisites** –Nuclear engineering physics, basic electricity and magnetism, and mathematics background at the graduate or advanced undergraduate level or **by instructor permission**. Also, undergrads must be certified to satisfy the undergrad graduation requirements, as defined by the MSE/NE Office of Academic Affairs.
3. **Course Objectives:** Following successful completion of this course, the student will have developed a useful understanding of the underlying principles involved in plasma physics and thermonuclear reactions. With this basis one will be able to assess the suitability to pursue other plasma-related course work.
4. **Contribution of course to meeting the professional component:**
This course provides 3 credits towards Engineering Sciences and nuclear energy development.
5. **Relationship of course to program outcomes:**
[This course integrates basic knowledge of mathematics, nuclear engineering science, and high energy-density physics to identify present and future national security challenges as they relate to the development of global nuclear energy.]
 - a. ABET Program Educational Objectives/Professional Components
 1. Graduates will have successful careers in Nuclear Engineering and related disciplines.
 2. Graduates will pursue advanced degrees or continuing education.
 - b. ABET Program Outcomes Supported
 - i. Outcome a: Ability to apply knowledge of mathematics, science, and engineering to nuclear energy concepts.
 - ii. Outcome d: Ability to function on multi-disciplinary teams; term project.
 - iii. Outcome f: Understanding of professional and ethical responsibility; nonproliferation will continue to be a global responsibility.
 - iv. Outcome g: Ability to communicate effectively in both oral and written form; term project presentation and oral final.
 - v. Outcome h: Understanding of the global, societal, and environmental impact of engineering solutions; fuel cycles, spent fuel solutions, and materials safeguards.
 - vi. Outcome j: Knowledge of contemporary issues; definitely a major contemporary and evolving issue.

See the following website for the current list of MSE outcomes:

<http://nuceng.ufl.edu/students/objectives-a-outcomes>

6. **Instructor:** Joseph M. Mack, Ph.D.
 - a. NSB 235
 - b. 352-846-1376; Cell: 505-231-6395; Home: 352-727-4562
 - c. jmack@mse.ufl.edu
 - d. No home web site
 - e. Office hours: Tuesdays, Thursdays 10-12
 - f. Walk-in or appointments by email or phone
 - g. Teaching Assistant: N/A
7. **Meeting Times:** T, 1:55 – 3:50 PM; TH, 3:00 – 3:50 PM, every week.
8. **Meeting Location:** Tuesdays: NSC 225; Thursdays: NSC 227
9. **Class/laboratory schedule:** N/A
10. **Material and Supply Fees:** None
11. **Textbooks and Software Required:**

Umran and Golkowski, **Principles of Plasma Physics for Engineers and Scientists**, 1st edition, ISBN: 978052119326 (hardback), Cambridge University Press, 2011.

Strongly recommended supplemental source: **The Physics of Plasmas**, T.J.M. Boyd, J.J. Sanderson: ISBN: 0521459125, Cambridge University Press, 2003.

Selected course notes will be provided, as warranted.

Recommended Supplemental Reading:

Plasma/Fusion Physics

Francis F. Chen, **Introduction to Plasma Physics and Controlled Fusion**, 2nd Edition, ISBN: 0-306-41332-9, 1984, Plenum (Springer) Press, New York, NY.

Spitzer, L., **The physics of Fully Ionized Gases**, ISBN 0-470-81723-2

Lindl, J., **Inertial Confinement Fusion: The Quest for Ignition and Energy Gain Using Indirect Drive**, ISBN: 156396662X

Lochte-Holtgreven, W., **Plasma Diagnostics**, ISBN: 1-56396-388-4, American Institute of Physics, 1995.

Huba, J.D., **NRL Plasma Formulary**, Beam Physics Branch, Plasma Physics Division, Naval Research Laboratory, Washington, DC, (2002).

Feynman, R.P., Leighton, R.B., and Sands, M., **The Feynman Lectures on Physics**, ISBN 0-201-02011-4, Addison-Wesley Publishing Company, 1964.

Clayton, D.D., **Principles of Stellar Evolution and Nucleosynthesis**, ISBN: 0226109534, University of Chicago Press, 1984.

12. **Course Outline:**

I. **Overview:**

- Course Introduction
- Review of basic tools

II. **Conceptual Plasma Physics:**

- Plasma definition
- Single-particle motion
- Macroscopic equations
- Plasma radiation
- Intro plasma kinetic theory
- Computational plasma physics

III. **Thermonuclear Reactions:**

- Reaction portfolio
- Uncontrolled TN reactions
- Controlled TN reactions

IV. **Fusion Concepts:**

- Ignition challenge
- Magnetic confinement fusion
- High energy-density physics
 - Inertial confinement fusion

V. **Diagnostics of Fusion Plasmas**

13. **Student presentations**

Adjustments in lecture topical coverage may be necessary to accommodate presentations and exams.

14. **Attendance and Expectations:**

Regular and active participation is paramount toward success in this course.

Attendance is expected, but will not be specifically marked off; however, excused absences are recommended. There will be material covered in class, including example problems, that is not in the text or the course handouts. It is your responsibility to make sure that you have complete class notes for any missed class. Missing class without a good reason is strongly discouraged. If a student anticipates missing a class, they should have someone pick up handouts or take notes, and let the instructor know beforehand.

Otherwise, a student should see the instructor afterward to get any handout material and the lecture content for that class period. Classmate pick up of handouts is also acceptable.

Operation of all cell phones, ipods, kindles, etc. is verboten with two exceptions: a note-taking device in which case the instructor must be able to see it too and a condition whereby a student anticipates a situation that might require communications during class. Check with the instructor before class for permission.

Students are asked to leave several chairs near the back of the classroom empty as class starts so that late arrivals can use them. Students are allowed to arrive late provided they do not disturb others and it does not occur frequently. Frequent tardiness will be addressed by instructor-student conference.

ALL email communication between student and instructor must be facilitated through the University of Florida system: jmack@mse.ufl.edu.

15. **Grading – methods of evaluation:** 100 points total

Take-home Questions: 20 points

Term Project: Written/oral term project (individual; format TBD) with presentation to class, to be selected from pre-arranged list or with instructor consent: 60 points

End-of-semester Assignment (format TBD): 20 points

16. **Grading Scale (intended to be consistent with e-learning)**

- a. A...95-100
- b. A-...90-95-
- c. B+...85-90-
- d. B....80-85-
- e. C+...75-80-
- f. C....70-75-
- g. D+...65-70-
- h. D....60-65-
- i. F....<60

Grades may be adjusted at the end of the course at the discretion of the instructor. Improvement over the course of the semester and classroom effort may be used to clarify close grade boundaries.

17. **Grading policies:** For more information on grades and grading policies, please visit: <https://catalog.ufl.edu/ugrad/current/regulations/info/grades.aspx>

18. **Make-up Exam Policy:** make-up exams are only given for exceptional circumstances and in accordance with University policy, and the request must be pre-approved by the lecturer.

19. Honesty Policy – UF students are bound by The Honor Pledge which states, “We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honor and integrity by abiding by the Honor Code. On all work submitted for credit by students at the University of Florida, the following pledge is either required or implied: “On my honor, I have neither given nor received unauthorized aid in doing this assignment.” The Honor Code (<http://www.dso.ufl.edu/sccr/process/student-conduct-honor-code/>) specifies a number of behaviors that are in violation of this code and the possible sanctions. Furthermore, you are obligated to report any condition that facilitates academic misconduct to appropriate personnel. If you have any questions or concerns, please consult with the instructor or TAs in this class.

Note that failure to comply with this commitment will result in disciplinary action compliant with the UF Student Honor Code Procedures.

See <http://www.dso.ufl.edu/sccr/procedures/honorcode.php>

20. Accommodation for Students with Disabilities – Students Requesting classroom accommodation must first register with the Dean of Students Office. That office will provide the student with documentation that he/she must provide to the course instructor when requesting accommodation.
21. UF Counseling Services –Resources are available on-campus for students having personal problems or lacking clear career and academic goals. The resources include:
UF Counseling & Wellness Center, 3190 Radio Rd, 392-1575,
<http://www.counseling.ufl.edu/cwc/Default.aspx>, counseling services and mental health services.
Career Resource Center, Reitz Union, 392-1601, career and job search services.
University Police Department 392-1111
22. Software Use – All faculty, staff and student of the University are required and expected to obey the laws and legal agreements governing software use. Failure to do so can lead to monetary damages and/or criminal penalties for the individual violator. Because such violations are also against University policies and rules, disciplinary action will be taken as appropriate. We, the members of the University of Florida community, pledge to uphold ourselves and our peers to the highest standards of honesty and integrity.
23. Students are expected to provide feedback on the quality of instruction in this course based on 10 criteria. These evaluations are conducted online at <https://evaluations.ufl.edu>. Evaluations are typically open during the last two or three weeks of the semester, but students will be given specific times when they are open. Summary results of these assessments are available to students at <https://evaluations.ufl.edu/results>.