

## **Fusion Plasmas**

ENU 6xxx Section # determined by registrar

**Class Periods:** Three days, one period per day. Details determined by registrar

**Location:** determined by registrar

**Academic Term:** Spring 2022

### ***Instructor:***

Associate Professor Chris McDevitt

[cmcdevitt@ufl.edu](mailto:cmcdevitt@ufl.edu)

(352) 846-3785

Office Hours: 174 Rhines Hall, 2 hours per week (days/times vary by semester)

### ***Teaching Assistants:***

N/A

### ***Course Description***

3 credit hours.

This course provides an introduction to the concepts underlying plasma confinement in fusion devices.

### ***Course Pre-Requisites / Co-Requisites***

PHY 2049 or instructor permission.

### ***Course Objectives***

1. Provide students with an understanding of the fundamentals of fusion energy science.
2. Give a broad account of the basic principles of plasma physics and their application to fusion devices
3. Prepare students to undertake research in a range of areas in plasma physics and fusion science

### ***Required Textbook***

- Introduction to Plasma Physics and Controlled Fusion
- Francis F. Chen
- 3<sup>rd</sup> Edition
- ISBN 978-3-319-22308-7

### ***Recommended Textbook***

- Plasma Physics and Fusion Energy
- Jeffrey Freidberg
- ISBN 978-0-521-73317-5

### ***Recommended Materials***

- NRL Plasma Formulary
- U.S. Naval Research Laboratory
- A pdf can be downloaded at: <https://www.nrl.navy.mil/ppd/content/nrl-plasma-formulary>

### ***Course Schedule***

Week 1: Light element fusion reactions and fundamentals of fusion power

Week 2: Cross sections, mean-free-path and the fusion reactivity integral

Week 3: Coulomb collisions and Bremsstrahlung radiation

HW 1

Week 4: Power balance and ignition criteria

Week 5: Approaches to fusion energy

HW 2 Exam 1

Week 6: Debye Shielding and plasma fundamentals

Week 7: Charged particle motion (1)

HW 3

Week 8: Charged particle motion (2)

Week 9: Plasmas as fluids (1)	HW 4
Week 10: Plasmas as fluids (2)	
Week 11: Magnetohydrodynamic equilibrium	Exam 2
Week 12: Waves in plasmas (1)	HW 5
Week 13: Waves in plasmas (2)	
Week 14: Fluid instabilities (1)	HW 6
Week 15: Fluid instabilities (2)	

#### Projects:

1. Exploring the ignition boundary. This project will focus on exploring how distinct physical processes impact the power balance in a fusion reactor, and thus the ignition threshold. Students will be required to develop increasingly realistic models of energy loss and gain processes, and identify the ignition threshold for each model considered. The deliverable will be a report, along with supporting computing files (Matlab/Python scripts, or similar programming language), that identify the ignition boundary and describe how critical parameters such as density, temperature, machine size and magnetic field strength influence the ignition threshold.
2. Identifying baseline parameters of a fusion device. This project will utilize the software written as part of project 1 to identify the maximum fusion gain attainable under a specified set of constraints. Specifically, an empirical scaling of transport processes in fusion devices will be provided by the instructor. The students will be tasked with identifying promising regions of the high dimensional parameter space available for fusion design, and selecting parameters for achieving high fusion gain subject to technological and monetary constraints. The deliverable will be a report listing the fusion parameters identified by the student, along with documentation describing the method used by the student to arrive at the identified fusion parameters.
3. Reactor design based on experimental data. Similar to project 2, the students will identify an optimal set of parameters for the design of a high gain fusion device. However, for this project, rather than an empirical scaling, the instructor will provide results from existing experimental devices. The student will need to derive their own empirical scaling relation via regression. Using this regression analysis, the student will determine an optimal set of parameters for the design of a high gain fusion device. The final report will consist of the design parameters, supporting code (Matlab, Python, or equivalent), and documentation describing the design considerations.

#### ***Attendance Policy, Class Expectations, and Make-Up Policy***

Class attendance is encouraged but not required. Excused absences are consistent with university policies in the graduate catalog <https://catalog.ufl.edu/graduate/regulations/> and require appropriate documentation.

#### ***Evaluation of Grades***

<b>Assignment</b>	<b>Percentage of Final Grade</b>
Homework Sets	30%
Projects 1, 2, and 3	20%
Exam 1	15%
Exam 2	15%
Final Exam	20%
	100%

Homework assignments will be posted on Canvas. The lowest homework score will be dropped. Students may work in groups. Two midterm exams will be given along with a final exam. Undergraduate and graduate versions of this course are differentiated by different homework and exams, along with a more comprehensive graduate project, although the courses share a common schedule. In particular, a third, more involved, project will be required (project 3 above), and additional problem(s) will be added to each homework assignment. The complexity of exam problems will also be adjusted for the graduate section compared to the undergraduate section.

### ***Grading Policy***

<b>Percent</b>	<b>Grade</b>	<b>Grade Points</b>
93.4 - 100	A	4.00
90.0 - 93.3	A-	3.67
86.7 - 89.9	B+	3.33
83.4 - 86.6	B	3.00
80.0 - 83.3	B-	2.67
76.7 - 79.9	C+	2.33
73.4 - 76.6	C	2.00
70.0 - 73.3	C-	1.67
66.7 - 69.9	D+	1.33
63.4 - 66.6	D	1.00
60.0 - 63.3	D-	0.67
0 - 59.9	E	0.00

More information on UF grading policy may be found at:

<http://gradcatalog.ufl.edu/content.php?catoid=10&navoid=2020#grades>

### ***Students Requiring Accommodations***

Students with disabilities requesting accommodations should first register with the Disability Resource Center (352-392-8565, <https://www.dso.ufl.edu/drc>) by providing appropriate documentation. Once registered, students will receive an accommodation letter which must be presented to the instructor when requesting accommodation. Students with disabilities should follow this procedure as early as possible in the semester.

### ***Course Evaluation***

Students are expected to provide professional and respectful feedback on the quality of instruction in this course by completing course evaluations online via GatorEvals. Guidance on how to give feedback in a professional and respectful manner is available at <https://gatorevals.aa.ufl.edu/students/>. Students will be notified when the evaluation period opens, and can complete evaluations through the email they receive from GatorEvals, in their Canvas course menu under GatorEvals, or via <https://ufl.bluera.com/ufl/>. Summaries of course evaluation results are available to students at <https://gatorevals.aa.ufl.edu/public-results/>.

### ***In-Class Recording***

Students are allowed to record video or audio of class lectures. However, the purposes for which these recordings may be used are strictly controlled. The only allowable purposes are (1) for personal educational use, (2) in connection with a complaint to the university, or (3) as evidence in, or in preparation for, a criminal or civil proceeding. All other purposes are prohibited. Specifically, students may not publish recorded lectures without the written consent of the instructor.

A “class lecture” is an educational presentation intended to inform or teach enrolled students about a particular subject, including any instructor-led discussions that form part of the presentation, and delivered by any instructor hired or appointed by the University, or by a guest instructor, as part of a University of Florida course. A class lecture does not include lab sessions, student presentations, clinical presentations such as patient history, academic exercises involving solely student participation, assessments (quizzes, tests, exams), field trips, private conversations between students in the class or between a student and the faculty or lecturer during a class session.

Publication without permission of the instructor is prohibited. To “publish” means to share, transmit, circulate, distribute, or provide access to a recording, regardless of format or medium, to another person (or persons), including but not limited to another student within the same class section. Additionally, a recording, or transcript of a recording, is considered published if it is posted on or uploaded to, in whole or in part, any media platform, including but not limited to social media, book, magazine, newspaper, leaflet, or third party note/tutoring services. A student who publishes a recording without written consent may be subject to a civil cause of action instituted by

a person injured by the publication and/or discipline under UF Regulation 4.040 Student Honor Code and Student Conduct Code.

### ***University 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 (<https://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.

### ***Commitment to a Safe and Inclusive Learning Environment***

The Herbert Wertheim College of Engineering values broad diversity within our community and is committed to individual and group empowerment, inclusion, and the elimination of discrimination. It is expected that every person in this class will treat one another with dignity and respect regardless of gender, sexuality, disability, age, socioeconomic status, ethnicity, race, and culture.

If you feel like your performance in class is being impacted by discrimination or harassment of any kind, please contact your instructor or any of the following:

- Your academic advisor or Graduate Program Coordinator
- Robin Bielling, Director of Human Resources, 352-392-0903, [rbielling@eng.ufl.edu](mailto:rbielling@eng.ufl.edu)
- Curtis Taylor, Associate Dean of Student Affairs, 352-392-2177, [taylor@eng.ufl.edu](mailto:taylor@eng.ufl.edu)
- Toshikazu Nishida, Associate Dean of Academic Affairs, 352-392-0943, [nishida@eng.ufl.edu](mailto:nishida@eng.ufl.edu)

### ***Software Use***

All faculty, staff, and students 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.

### ***Student Privacy***

There are federal laws protecting your privacy with regards to grades earned in courses and on individual assignments. For more information, please see: <https://registrar.ufl.edu/ferpa.html>

### ***Campus Resources:***

#### ***Health and Wellness***

##### **U Matter, We Care:**

Your well-being is important to the University of Florida. The U Matter, We Care initiative is committed to creating a culture of care on our campus by encouraging members of our community to look out for one another and to reach out for help if a member of our community is in need. If you or a friend is in distress, please contact [umatter@ufl.edu](mailto:umatter@ufl.edu) so that the U Matter, We Care Team can reach out to the student in distress. A nighttime and weekend crisis counselor is available by phone at 352-392-1575. The U Matter, We Care Team can help connect students to the many other helping resources available including, but not limited to, Victim Advocates, Housing staff, and the Counseling and Wellness Center. Please remember that asking for help is a sign of strength. In case of emergency, call 9-1-1.

**Counseling and Wellness Center:** <http://www.counseling.ufl.edu/cwc>, and 392-1575; and the University Police Department: 392-1111 or 9-1-1 for emergencies.

**Sexual Discrimination, Harassment, Assault, or Violence**

If you or a friend has been subjected to sexual discrimination, sexual harassment, sexual assault, or violence contact the [Office of Title IX Compliance](#), located at Yon Hall Room 427, 1908 Stadium Road, (352) 273-1094, [title-ix@ufl.edu](mailto:title-ix@ufl.edu)

**Sexual Assault Recovery Services (SARS)**

Student Health Care Center, 392-1161.

**University Police Department** at 392-1111 (or 9-1-1 for emergencies), or <http://www.police.ufl.edu/>.

**COVID-19**

- You are expected to wear approved face coverings at all times during class and within buildings even if you are vaccinated.
- If you are sick, stay home and self-quarantine. Please visit the UF Health Screen, Test & Protect website about next steps, retake the questionnaire and schedule your test for no sooner than 24 hours after your symptoms began. Please call your primary care provider if you are ill and need immediate care or the UF Student Health Care Center at 352-392-1161 (or email [covid@shcc.ufl.edu](mailto:covid@shcc.ufl.edu)) to be evaluated for testing and to receive further instructions about returning to campus.
- If you are withheld from campus by the Department of Health through Screen, Test & Protect, you are not permitted to use any on campus facilities. Students attempting to attend campus activities when withheld from campus will be referred to the Dean of Students Office.
- UF Health Screen, Test & Protect offers guidance when you are sick, have been exposed to someone who has tested positive or have tested positive yourself. Visit the [UF Health Screen, Test & Protect website](#) for more information.
- Please continue to follow healthy habits, including best practices like frequent hand washing. Following these practices is our responsibility as Gators.

**Academic Resources**

**E-learning technical support**, 352-392-4357 (select option 2) or e-mail to [Learning-support@ufl.edu](mailto:Learning-support@ufl.edu).  
<https://lss.at.ufl.edu/help.shtml>.

**Career Resource Center**, Reitz Union, 392-1601. Career assistance and counseling. <https://www.crc.ufl.edu/>.

**Library Support**, <http://cms.uflib.ufl.edu/ask>. Various ways to receive assistance with respect to using the libraries or finding resources.

**Teaching Center**, Broward Hall, 392-2010 or 392-6420. General study skills and tutoring.  
<https://teachingcenter.ufl.edu/>.

**Writing Studio, 302 Tigert Hall**, 846-1138. Help brainstorming, formatting, and writing papers.  
<https://writing.ufl.edu/writing-studio/>.

**Student Complaints Campus**: [https://www.dso.ufl.edu/documents/UF\\_Complaints\\_policy.pdf](https://www.dso.ufl.edu/documents/UF_Complaints_policy.pdf).

**On-Line Students Complaints**: <http://www.distance.ufl.edu/student-complaint-process>.