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NE/PY 528 Course Syllabus

Introduction to Plasma Physics and Fusion Energy

Fall 2025 Semester, 3 Credit Hours

Instructor Information

Name	Role	Office Phone	Email	Office Location
Dr. Florian M. Laggner	Instructor	(919) 51 33603	fmlaggner@ncsu.edu	Burlington Laboratories 3152
Nusrat Karim	Teaching Assistant	-	nkarim@ncsu.edu	Burlington Laboratories



F. M. Laggner
(Instructor)



Nusrat Karim
(Teaching Assistant)

Office Hours

F. M. Laggner:

Mon, 10 AM - 11 AM, 3152 Burlington Laboratories

Wed, 3 PM - 4 PM, 3152 Burlington Laboratories

N. Karim:

TBA, 2106 Burlington Laboratories (NE Library)

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Preferred Method of Communication & Response Time

- **Preferred method of communication:** If you need to contact the instructor(s) directly, the preferred method of communication is email. Typical response time via email is within 24 h during the week. Do not expect any email communication on weekends. If an instructor emailed you directly, please strive to respond within 24 h. Highly recommended that you check your NC State email at least once a day to stay on top of course communications.
- **Asking questions about the course:** If you have a question about the course or its content, please post your question on the Student Help Forum in Moodle. You can expect to receive a response within 24 h during the week (i.e. not over the weekend).
- **Email guidelines:** Always include a descriptive, specific but concise subject. Include your course number in your email, and provide adequate context for your question in order to ensure full understanding of your email. Be sure to use your NC State email account, and sign with your name and Student ID number.

Course Information

Course Website: <https://moodle-courses2527.wolfware.ncsu.edu/course/view.php?id=372>

Meeting Time and Location: Monday and Wednesday, 1:30 PM – 2:45 PM, Room 327 111 Lampe Drive

Course Calendar: The Moodle calendar will be kept up to date and it can be exported to any desired platform; see https://docs.moodle.org/402/en/Using_Calendar. It is recommended to use 'Dynamic Link to Moodle Calendar'.

Catalog Description

Concepts in plasma physics, basics of thermonuclear reactions; charged particle collisions, single particle motions and drifts, radiation from plasmas and plasma waves, fluid theory of plasmas, formation and heating of plasmas, plasma confinement, fusion devices and other plasma applications.

Structure

This course is delivered in a **hybrid** format, meaning it has asynchronous and synchronous components. Asynchronous components (homework assignments) are delivered through **Moodle**, a secure and easy-to-use online learning platform.

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This course has 5 units, typically one of them is taught over two to three weeks.

Unit	Unit title	Course Content	Week
I	Introduction	Fusion in stars and in a fusion reactor Reaction rates Energy gain Fusion triple product Characteristics of plasmas Saha equation and ionization equilibrium Plasma frequency and collective behavior Debye length and plasma shielding	1-2
II	Single Particle Motion	Lorentz force equation Particle trajectories in uniform fields Behavior in non-uniform fields Particle drifts Adiabatic invariance	3-4
III	Plasma Fluid Theory	Introduction to the kinetic problem Moments of the Boltzmann equation Plasma fluid dynamics Diamagnetic drift Introduction to waves Perturbation analysis and plasma wave phenomena Transport processes Magnetohydrodynamic (MHD) theory Ideal MHD approximation 'Frozen-In' flux concept	5-10
IV	Plasma Instabilities	Stability criteria Electrostatic instabilities - Two stream instability MHD instabilities - Rayleigh-Taylor instability	11-12
V	Plasma Confinement And Fusion Technology	Confinement concepts Inertial confinement fusion (ICF) Magnetic confinement fusion (MCF) - Tokamaks MCF - Stellarators Plasma material interaction (PMI) Fuel cycle and breeding blankets	13-14

Prerequisites/Corequisites

MA 401 and PY 208

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Minimum Technical and Digital Information Literacy Skills

Required technical Skills

- Navigate and use Moodle, NC State's Learning Management System.
- Use Gmail, including attaching files to email messages
- Create and submit files in commonly used word processing program formats (MS Word, text editors, Google Docs).
- Download and upload attachments
- Use spreadsheet, presentation, graphics programs and other applications in digital environments
- Use web conferencing tools including Zoom.
- Post to discussion boards and forums

Required digital information literacy skills

- Perform online research using various search engines and library databases. Visit [Distance Learning Services](#) at NC State Libraries for more information.
- Use computer networks to locate and store files or data.
- Use online search tools for specific academic purposes, including the use of search criteria, keywords and filters
- Analyze digital information for credibility, currency, and bias (e.g. disinformation, misinformation)
- Properly cite information sources

Learning Outcomes

Understand concepts in plasma physics and basics of thermonuclear reactions.

Upon completion of this course, students will be able to:

1. Understand the fundamentals of fusion reactions, including reaction rates and energy gain.
2. Comprehend basic plasma physics principles and characteristics.
3. Analyze single particle motion in plasmas, including various particle drifts and adiabatic invariance.
4. Derive and interpret fluid equations for plasmas, including dispersion relations.
5. Examine various types of waves in plasmas, including cold plasma waves.
6. Classify and analyze different types of plasma instabilities.
7. Analyze magnetized plasma behavior using magnetohydrodynamic (MHD) theory
8. Compare and contrast different plasma confinement approaches in fusion

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Course Materials

Textbooks

Textbooks are optional (Free online access for NCSU students):

[U] 'Principles of Plasma Physics for Engineers and Scientists' U. S. Inan and M. Golkowski,

1st Edition, ISBN: 978-0-521-19372-6 <https://catalog.lib.ncsu.edu/catalog/NCSU4450335>

[C] 'Introduction to Plasma Physics and Controlled Fusion' F. Chen, 3rd Edition,

ISBN:978-3-319-22309-4 <https://catalog.lib.ncsu.edu/catalog/NCSU3556298>

Technology Requirements

NC State University Libraries offers [Technology Lending](#), where many devices are available to borrow for a 7-day period. [Computer labs](#) are available in various locations around campus for student use.

Computer

A laptop computer is recommended for students taking this course. NC State's Online and Distance Education provides [technology requirements and recommendations](#) for computer hardware, and NC State's Office of Information Technology provides recommendations for [your computer at NC State](#).

Other devices

Not required.

Software and digitally-hosted course components

The following software and tools will be used in this course. Some tools are a part of NC State's enterprise tools. See [information about their purpose, how to access them, accessibility information, and privacy policies](#). The same information for any other tools required in this course is provided in the list below.

- **Moodle**
 - **Purpose:** Learning Management System used to host course materials, activities and more.
 - **How to access:** Login with your UnityID to [WolfWare](#) and click on a course title to be taken to the course site.
 - **Accessibility:** [Moodle Accessibility Statement](#)
 - **Privacy:** [Moodle Privacy Policy](#)

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- **Gradescope**
 - **Purpose:** Assignment collection and grading as well as exam grading.
 - **How to access:** Linked through Moodle
 - **Accessibility:** [Gradescope Accessibility Information and Resources](#)
 - **Privacy:** [Privacy Policy | Gradescope](#)
- **Panopto**
 - **Purpose:** Video repository of lectures.
 - **How to access:** Linked through Moodle; also available at [Panopto at NC State](#)
 - **Accessibility:** [Learn About Panopto Accessibility Features](#)
 - **Privacy:** [Privacy Policies - Panopto Video Platform](#)
- **Zoom**
 - **Purpose:** Course participation for distance education students (optional).
 - **How to access:** Via shared link with eligible attendees. You can also access your [NC State Zoom dashboard](#)
 - **Accessibility:** [Accessibility | Zoom](#)
 - **Privacy:** [Zoom's privacy statement](#)

Other Student Expenses

- None

Communication Guidelines

Respecting our learning community

The [NC State Code of Student Conduct](#) outlines expectations for behavior in the classroom (whether virtual or physical) and the consequences for students who violate these expectations. Any behavior that impacts other students' ability to learn and success will be addressed, but expressing diverse viewpoints and interpretations of course content is welcome.

Community guidelines for this course include:

- Use a respectful tone in all forms of communication (email, written, oral, visual)
- Maintain professionalism (avoid slang, poor grammar, etc.) in your written communication.
- Respect regional dialects and culturally embedded ways of oral communication.
- Stay home or in your dorm room if you are exhibiting symptoms of a contagious illness (fever, chills, etc.).
- Enter our virtual and/or physical classroom community respectfully by refraining from lewd or indecent speech or behavior, helping to maintain a safe physical environment, not using your cell

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phone for voice or text communication except when explicitly given leave to do so, and not attending class under the influence of any substance.

- Treat each community member with respect by not recording others without their consent or engaging in any form of hazing or harassment or intimidation or abuse.
- Respect cultural differences that may influence communication styles and needs.

Grading and Feedback

Grading criteria, details, and timing of feedback

Percentage of grade	Component	Details and timing of feedback
35 %	Homework	<ul style="list-style-type: none">• Students will submit homework individually.• <i>The homework problems will be typically made available on Monday and they are due Wednesday two weeks later at 1:30 PM Eastern Time.</i>• Requests for regrades are only accepted when they include a written justification and must be submitted not later than 1 week after the homework was returned.*• <i>The tentative assignment schedule can be found under 'Course Schedule'.</i>
40 %	Midterm Exams (20 % each)	<ul style="list-style-type: none">• <i>Midterm exams are closed book, in-class and timed.</i>• <i>You are allowed one handwritten, double-sided 8.5x11 study sheet for each exam along with a scientific calculator.</i>• <i>You will receive a grade / feedback within two weeks of the due date.*</i>
25 %	Final Exam	<ul style="list-style-type: none">• <i>The final exam is closed book, in-class and timed.</i>• <i>You are allowed one handwritten, double-sided 8.5x11 study sheet along with a scientific calculator.</i>• <i>You will receive a grade / feedback within two weeks of the due date.*</i>

*modifications to the timing of grades/feedback, if required, will be announced via the Moodle Forum.

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Grading scale

This course uses this grading scale:

Low	Letter	High
95 ≤	A+	≤ 100
90 ≤	A	< 95
85 ≤	A-	< 90
80 ≤	B+	< 85
76 ≤	B	< 80
72 ≤	B-	< 76
68 ≤	C+	< 72
64 ≤	C	< 68
60 ≤	C-	< 64
56 ≤	D+	< 59
52 ≤	D	< 56
48 ≤	D-	< 52
0 ≤	F	< 48

Requirements for earning a grade of “Satisfactory”

If you are taking this course for credit only (S/U), your grade will be reported as S (Satisfactory) when coursework is equivalent to a C- or better or U (Unsatisfactory) when coursework is equivalent to less than a C-. For more information, see the [Credit Only Courses regulation](#).

Requirements and procedures for auditing this course

Auditing this course is approved on a case-by-case basis. Please contact the course instructor to attain approval. Refer to the [Audit regulation](#) for more information and links to required forms.

Important Dates

Please refer to the NCSU Academic Calendar for important dates (<https://studentservices.ncsu.edu/calendars/academic/>).

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Important dates include: Last day to add/drop a class, Last day to withdraw without a "W", Last day to change from credit to audit or audit to credit, etc.

For course-related important dates, see the course schedule section. The schedule is subject to change with fair notice. The schedule will be updated regularly and posted on Moodle.

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Course Schedule

Please note that this schedule is tentative and subject to change with fair notice. The schedule is updated regularly and will be posted on Moodle.

Class	Dates	Class Detail	Reading (optional)	HW assigned	HW due	HW return
1	Mon, Aug-18	Introduction to Fusion	[C] 1.3, 10.1			
2	Wed, Aug-20	Reaction Rates				
3	Mon, Aug-25	Triple Product, Lawson Criterion	[C] 10.2.1	1		
4	Wed, Aug-27	Introduction to Plasmas	[U] 1, ([C] 1)			
	Mon, Sep-01	LABOR DAY – NO CLASS		-		
5	Wed, Sep-03	Single Particle Motion	[U] 2, ([C] 2.1)			
6	Mon, Sep-08	Particle Drifts	[U] 2.2, 2.3 ([C] 2.3 - 2.7)	2		
7	Wed, Sep-10	Adiabatic Invariance	[U] 2.4 ([C] 2.8))		1	
8	Mon, Sep-15	Introducing to Kinetic Problem	[U] 3.3-3.6	-		
9	Wed, Sep-17	Moments of Boltzmann Equ.	[U] 4.1-4.4, 5.2, 13.4			1
10	Mon, Sep-22	Diamagnetic Drift	[U] 5.3 ([C] 3.4)	3		
11	Wed, Sep-24	Waves, Dispersion Relation	[U] 9.1, ([C] 4.1- 4.2)		2	
12	Mon, Sep-29	MIDTERM EXAM 1		-		
13	Wed, Oct-01	Electrostatic Waves	[U] 4.2, 10.1-10.2 [C] 4.3			2
14	Mon, Oct-06	Transport, Plasma Diffusion	[U] 8.1 - 8.3	4		
15	Wed, Oct-08	Magnetohydrodynamics	[U] 6.1, 6.2		3	
	Mon, Oct-13	FALL BREAK – NO CLASS		-		
16	Wed, Oct-15	MHD Diffusion	[U] 8.3 ([C] 5.5, 5.10)			3
17	Mon, Oct-20	Frozen-in magnetic flux lines	[U] 6.4.1, 11.3	5		
18	Wed, Oct-22	MHD Force Balance	[U] 6.5, 6.6		4	
19	Mon, Oct-27	Stability, Two Stream Instability	[C] 6.5, [U] 12.2.3	-		
20	Wed, Oct-29	Rayleigh–Taylor Instability	[C] 6.7			4
21	Mon, Nov-03	MIDTERM EXAM 2		-		
22	Wed, Nov-05	Bremsstrahlung			5	
23	Mon, Nov-10	Fusion Concepts		6		
24	Wed, Nov-12	Inertial Confinement Fusion	[C] 10.4			5
25	Mon, Nov-17	MCF: Tokamaks	[C] 10.2.1.5	-		
26	Wed, Nov-19	MCF: Stellarators	[C] 10.2.1.4			
27	Mon, Nov-24	Fusion Fuel Cycle & Blankets		-		
	Wed, Nov-26	THANKSGIVING – NO CLASS			6	
28	Mon, Dec-01	Review		-		
	Wed, Dec-03	READING DAY - NO CLASS				6
29	Wed, Dec-10	FINAL EXAM				

Note on reading recommendations:

[U] 'Principles of Plasma Physics for Engineers and Scientists' U. Inan and M. Golkowski, 1st Edition

[C] 'Introduction to Plasma Physics and Controlled Fusion' F. Chen, 3rd Edition

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Course Policies

Proctored exams

Exams are closed book, in-class and timed. You are allowed one double-sided 8.5x11 'cheat sheet' for each exam along with a scientific calculator.

Extensions and late assignments

Extensions on assignments beyond the due date can be requested without penalty. **A written justification needs to be provided at least 3 business days before the assignment is due**, which is Friday 1:30 PM Eastern Time of the week before the submission is due. Exceptions to this deadline can be made in extraordinary circumstances, e.g. unforeseen health conditions.

Late or incomplete submissions of homework assignments will be **graded a "zero" grade**.

Incomplete grades, withdrawals

Information on incomplete grades can be found at [REG 02.50.03 – Grades and Grade Point Average](#). If you encounter a serious disruption to your work not caused by you and you would have otherwise successfully completed the course, contact your instructor as soon as you can to discuss the possibility of earning an incomplete in the course for the semester, including an agreement on when the remaining work must be done in order to change the grade to the appropriate letter grade.

If you student must withdraw from a course or from the University due to hardship beyond their control, see [Withdrawal Process and Timeline | Student Services Center](#) for information and instructions.

Attendance

- Students participation in class enhances the learning experience not only for the individual but for the class as a whole.
- **Students are expected to regularly attend lectures.**
 - Make-up work for missed classes include watching the full online recordings of the missed lectures.
- Students may be asked to provide documentation for multiple consecutive class absences or frequent single class absences.

Related NC State Policy: [REG 02.20.03 – Attendance Regulations](#)

Use of Artificial Intelligence (AI) Tools and Tutoring Services

In this course, you are expected to complete all assignments, projects, and assessments independently, demonstrating your own understanding and analysis of the course material.

You may not use any artificial intelligence (AI) tools (e.g., chatbots, text generators, paraphrasers, summarizers, code/solution generators) or online tutoring services (e.g., Chegg, Course Hero) to complete any portion of your assignments.

It is strictly prohibited to upload or share any course materials, particularly homework problems, lecture slides, or exams to any AI tool, website, or tutoring platform.

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Potentially permitted AI uses:

- Research assistance: Using AI tools for secondary literature searches, filtering references, and prioritizing readings.
- Study aid: Using AI tools to clarify concepts or test your own understanding through explanations.

Any use of AI tools or tutoring services beyond what is explicitly permitted will be considered academic misconduct and handled according to the University's Academic Integrity Policy.

No tool can replace your own thinking, reasoning, and analysis. If in doubt about acceptable use of AI, consult the instructor before using any tool or service.

University Policies

Academic integrity and honesty

Students are required to comply with the university policy on academic integrity found in the [Code of Student Conduct 11.35.01 sections 8 and 9](#). Therefore, students are required to uphold the Pack Pledge: "I have neither given nor received unauthorized aid on this test or assignment." Violations of academic integrity will be handled in accordance with the [Student Discipline Procedures](#).

Please refer to the [Academic Integrity](#) web page for a detailed explanation of the University's policies on academic integrity and some of the common understandings related to those policies.

Student privacy

Originality Checking Software

- ☐ Software is being used in this course to detect the originality of student submissions.
- ☒ Software is not used in this course to detect originality of student submissions.

Class recording statement:

- ☐ In-class sessions are recorded in such a way that might also record students in this course. These recordings will NOT be used beyond the current semester or in any other setting outside of the course.
- ☒ In-class sessions are recorded in such a way that might also record students in this course. These recordings MAY be used beyond the current semester or in any other setting outside of the course. Contact your instructor if you have concerns.
- ☐ Students will not be able to be identified in any course recordings, or the course will not be recorded at all.

Class privacy statement:

- ☒ This course requires online exchanges among students and the instructor, but NOT with persons outside the course. Students may be required to disclose personally identifiable information to other students in the course, via electronic tools like email or web-postings, where relevant to the course. Examples include online discussions of class topics and posting of student coursework. All students are expected to respect the privacy of each other by not sharing or using such information outside the course.

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- ☐ Student information in this course may be accessible to persons beyond the instructor and students in the course. This course may involve electronic sharing or posting of personally identifiable student work or other information with persons not taking or administering the course. Students will be asked to sign a consent form allowing disclosure of their personally identifiable work. No student is required to sign the consent form as a condition of taking the course. If a student does not want to sign the consent form, he or she has the right to ask the instructor for an alternative, private means of completing the coursework.

Other policies

Students are responsible for reviewing the NC State University PRR's which pertains to their course rights and responsibilities:

- [Equal Opportunity and Non-Discrimination Policy Statement](#) and [additional references](#)
- [Code of Student Conduct](#)
- [Grades and Grade Point Average](#)
- [Credit-Only Courses](#)
- [Audits](#)

Student Resources

Academic and Student Affairs maintains a website with links for student support on campus, including academic support, community support, health and wellness, financial hardship or insecurity, and more. [Find Help on Campus.](#)

Disability resources

Reasonable accommodations will be made for students with verifiable disabilities. In order to take advantage of available accommodations, students must register with the [Disability Resource Office \(DRO\)](#). For more information on NC State's policy on working with students with disabilities, please see the [Policies, Rules and Regulations page maintained by the DRO](#) and [REG 02.20.01 Academic Accommodations for Students with Disabilities](#).

Safe at NC State

At NC State, we take the health and safety of students, faculty and staff seriously. The [Office for Institutional Equity and Diversity](#) supports the university community by providing services and resources to support and guide individuals in obtaining the help they need. See the [Safe at NC State webpage](#) for resources.

Supporting Fellow Students in Distress

[Example: As members of the NC State Wolfpack community, we each share a personal responsibility to express concern for one another and to ensure that this classroom and the campus as a whole remains a healthy and safe environment for learning. Occasionally, you may come across a fellow classmate whose personal behavior concerns or worries you, either for the classmate's well-being or yours. If you feel this way, I would encourage you to report this behavior to the [NC State CARES website](#). Although you can

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report anonymously, it is preferred that you share your contact information so they can follow-up with you personally.]

Course Evaluations

ClassEval is the end-of-semester survey for students to evaluate instruction of all university classes. The current survey is administered online and includes 12 closed-ended questions and 3 open-ended questions. Deans, department heads, and instructors may add a limited number of their own questions to these 15 common-core questions.

Each semester students' responses are compiled into a ClassEval report for every instructor and class. Instructors use the evaluations to improve instruction and include them in their promotion and tenure dossiers, while department heads use them in annual reviews. The reports are included in instructors' personnel files and are considered confidential.

Online class evaluations will be available for students to complete during the last two weeks of the semester for full semester courses and the last week of shorter sessions. Students will receive an email directing them to a website to complete class evaluations. These become unavailable at 8am on the first day of finals.

- Contact ClassEval Help Desk: classeval@ncsu.edu
- [ClassEval website](#)
- [More information about ClassEval](#)

Syllabus Modification Statement

Our syllabus represents a flexible agreement. It outlines the topics we will cover and the order we will cover them in. Dates for assignments represent the earliest possible time they would be due. The pace of the class depends on student mastery and interests. Thus minor changes in the syllabus can occur if we need to slow down or speed up the pace of instruction. Schedule changes will be announced via email with fair notice.