**NPRE 423: Plasma Laboratory**

**Fall 2025**

**Course description:**

Experiments relating to plasma engineering and fusion energy. Topics in ultra-high vacuum technology rf and dc electric plasma probes, measurements of dc and pulsed magnetic fields, dynamics of a theta pinch, and laser interferometry to measure plasma density. Course Information: 2 undergraduate hours. 2 graduate hours. Prerequisite: NPRE 421 and NPRE 451.

**Staff:**

Instructors: Prof. Mohan Sankaran, 111H Talbot Lab, [rmohan@illinois.edu](mailto:rmohan@illinois.edu)

TAs: Aleksandr Khomiakov, 113 NRL, akk11@illinois.edu

Emily Greene, 109 NRL, emilybg2@illinois.edu

Gia Mien Lee, 106A NRL, gvle2@illinois.edu

**Lectures:**

Lectures: Th 12:30-1:50 pm, 139 Loomis Laboratory

Lab sections: T 12-3:50 pm (ABB), W 4-7:50 pm (ABA), Th 4-7:50 pm (ABC), NRL

**Course materials:**

* Required texts: *Electric Probes for Low-Temperature Plasmas*, D. N. Ruzic

(provided free)

*Principles of Plasma Discharges and Material Processing*, M. A. Liebermann and A. J. Lichtenberg

* Suggested references: A User's Guide to Vacuum Technology, J. F. O'Hanlon

Pumps Used in Vacuum Technology, H. G. Tompkins and T. A. Gessert

Introduction to Plasma Physics and Controlled Fusion, F. F. Chen

**Course grading:**

90% Technical written reports and Oral presentation

5% Prelabs

5% Group participation

\*There are a total of 9 labs and each will be ~11% of your total grade.

Written and oral communication skills are critical for an engineer to be successful. A major objective of this course is to strengthen technical communication skills. A technical written report will be required for 8 of the 9 experiments, due one week after you do the lab, with a hard deadline of the start of your next lab (Tuesday at 12 pm if you are in the Tuesday 12-3:50 pm section, etc.). In some special cases, you will have two weeks to submit the report – we will let you know. All but one of these reports will be individual (each of you is required to prepare and submit your own report and you will receive an individual grade). The remaining report will be a group effort (each group is required to collaboratively prepare and submit a report and the group will receive one grade). An oral presentation will be required for 1 of the 9 experiments. The presentation will be a group effort where each member must present a part of the presentation in one collective and cohesive presentation and the group will receive one grade.

In addition to these reports and presentations, there will be a prelab requirement at the start of each lab (before you actually do the experiment). Each group, led by a foreman, will need to show an Excel spreadsheet prepared with column headers to fill in and as appropriate analyze data in real time during the lab. In addition, the group will need to prepare or be ready to answer 3 to 5 questions addressing theory, operation, and safety associated with the labs.

You are expected to work together during the lab. There is a lab participation grade based on the level of engagement by each group member, and how well you work together (additional details below). You will also need to assign a foreman for each lab, and each group member must serve as a foreman for at least one lab. The foreman will be responsible for preparing the prelab spreadsheet, and assigning roles to each member during the lab (someone to change experimental conditions, someone to record observations or data, etc.). After the lab, you are encouraged to work together on data analysis. For example, you can discuss how to apply theory, plot data, and even compare results after analysis with one another. However, the individual reports are to be prepared independently of your group members or other classmates, including all the figures and tables, and much of the deeper analysis and organization of the report. You should not share your reports, even drafts, with your own group or other groups. You should also not find and use lab reports from previous years. Many of the labs have changed, all of the TAs have taken the class before, and it is a small class, so we will easily be able to tell if the report is not original! Additional details about academic integrity policy are provided below.

If you have registered for NPRE 498 PL1, you must meet with a TA after your lab section and before your report is due to discuss data analysis and receive the extra credit hour. In particular, we are recommending that you prepare a key figure based on results to be reviewed by the TA. Each of the TAs will have office hours for these meetings and to answer any other questions about the lab, data analysis, and preparing the report. Those in Tuesday lab sections should generally meet with TAs on Fridays, and those in Wednesday and Thursday lab sections should generally meet with TAs on Mondays. If you come at the last minute (Monday before your lab report is due on Tuesday), we cannot guarantee that the TA will be available or answer your questions and we will prioritize those that are coming on the normal time and are preparing in advance. In special cases, you may email the figure to your TA to receive approval and not need to attend the office hours in person. You cannot email the TA less than 48 hours before your report is due and expect to receive approval or have your questions answered. Remember that the TAs are also graduate students who are working on their thesis projects.

If you have registered for NPRE 498 PL2, you can do your special project using one of the systems that was part of the regular labs after all the regular labs are completed (tentatively scheduled the week after Thanksgiving). Please think about the project beforehand as you are doing each experiment and discuss with the TAs and Prof. Sankaran so we are aware what you would like to do and are planning. We will help guide you so that the experiments are realistic and feasible to be completed in one lab section.

Technical written report and prelab submission:

The technical written reports must be word processed and turned in electronically via Canvas before the start of your next lab section. The penalty for a late lab report is 10% each day for the first 5 days. If your report is more than 5 days late, you must discuss with Prof. Sankaran to make special arrangements or the report will not be accepted and you will receive a 0%. Failure to submit all lab reports before the end of the semester will result in a grade of “Incomplete”. Incomplete grades become failing grades (F) halfway through the following semester.

There is no submission for the prelabs, but you will need to show an Excel sheet on one of your laptops and answer questions in person.

More detailed guidelines for the prelabs and the technical reports are provided in separate documents.

**Laboratory experiments:**

Lab 1: (AP) Atmospheric-pressure plasmas – MRL 129 – Gia Mien (Sasha)

**Lab 2: (VT) Vacuum technology – NRL 114 (HELM) – Sasha (Gia Mien)**

Lab 3: (DC) DC glow discharges – DC glow chamber, NRL 103 – Emily (Sasha)

**Lab 4: (RF) RF glow discharges – RF glow chamber, NRL 103 – Sasha (Gia Mien)**

Lab 5: (SPEC) Spectroscopy – NRL 114 (HERM) – Sasha (Gia Mien)

**Lab 6: (LP/TLP) Single and triple Langmuir probes – NRL 114 (HELM) – Gia Mien (Sasha)**

Lab 7: (ETCH) Etching – NRL 114 – Emily (Gia Mien)

**Lab 8: (PVD) Physical vapor deposition – DEPO chamber, NRL 103 – Emily (Sasha)**

Lab 9: (HIDRA) Fusion lab – HIDRA, 114 NRL – Gia Mien (Emily)

\*Labs in boldface will be group reports. Also, you will choose one of them to be presented in class as an oral presentation.

**Lab participation:**

You are expected to arrive for your lab section on time, be prepared (watch the lectures before hand and read the lab manuals!), participate equally (for each experiment and throughout the semester for all experiments), be aware of safety, and be professional (both in attire and behavior). You will be assessed over the semester equivalent to 5% of your total grade by individual feedback from your group members and observation by the TAs and instructors.

Everyone should read the appropriate lab manual before attending the section. It is best for the foreman to have a copy of the lab manual available during the lab section. Every student is expected to bring a notebook or paper and take careful notes during the experiments. Please note that some experiments have data acquisition on computers, others do not. Some instruments require manual reading of the measurements. Each group should bring at least one USB stick to transfer computer recorded data. Each person should make a copy of the data before leaving the section.

Long pants and close-toed shoes are required in the lab, per lab safety requirements. Be careful and learn a lot. You will be using state-of-the-art equipment that, in many cases, is being actively used for research. Keep in mind that if something breaks, it will likely delay someone’s graduation. On the other hand, this lab class will be a great opportunity to see how equipment in a real research lab works and for you to gain valuable experience.

**Safety certificates:**

In order to ensure that we maintain the highest safety standards in the laboratory, everyone is required to undergo mandatory safety training found on the DRS website at: http://www.drs.illinois.edu/Training. The trainings that need to be completed are as follows:

* Laboratory Safety Training Parts 1 and 2
* Chemical Safety: An Introduction
* Electrical Safety: Fundamentals
* Electrical Safety: Recommend Practices

You must submit the certificates you received after completing the modules by email before the first lab section.

**Emergency response recommendations:**

Emergency response recommendations can be found at the following website: http://police.illinois.edu/emergency-preparedness/.

I encourage you to review this website and the campus building floor plans website within the first 10 days of class. <http://police.illinois.edu/emergency-preparedness/building-emergency-action-plans/>.

**Academic integrity:**

The University of Illinois at Urbana-Champaign Student Code should also be considered as a part of this syllabus. Students should pay particular attention to Article 1, Part 4: Academic Integrity. Read the Code at the following URL: http://studentcode.illinois.edu/.

Academic dishonesty may result in a failing grade. Every student is expected to review and abide by the Academic Integrity Policy: https://studentcode.illinois.edu/article1/part4/1-401/. Ignorance is not an excuse for any academic dishonesty. It is your responsibility to read this policy to avoid any misunderstanding. Do not hesitate to ask the instructor(s) if you are ever in doubt about what constitutes plagiarism, cheating, or any other breach of academic integrity.

**Lab schedule:**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Week of (date is Monday)** | **Tuesday Lab (ABB)**  **(12-3:50)** | **Tuesday Lab (ABD) (4-7:50)** | **Wednesday Lab (ABA) (4-7:50)** | **Thursday Lecture**  **(12:30-1:50)** | **Thursday Lab (ABC)**  **(4-7:50)** |
|  | **Emily** |  | **Sasha** |  | **Gia Mien** |
|  | Carlson, Gerrity, Hackett, Lehman, Velapatin, Ringstad |  | Baird, Egly, Kino, Landrum, Shih |  | Furlin, Jeckell, A. Kim, S. Kim, Namba, Comer |
| **8/25** |  |  |  | Introduction |  |
| **9/1** | AP |  | AP | AP | AP |
| **9/8** | VT |  | VT | VT | VT |
| **9/15** | DC |  | DC | DC | DC |
| **9/22** | RF |  | RF | RF | RF |
| **9/29** |  |  |  |  |  |
| **10/6** | Spectroscopy |  | Spectroscopy | Spectroscopy | Spectroscopy |
| **10/13** | LP |  | LP | LP | LP |
| **10/20** | LP |  | LP | LP | LP |  |  |  |
| **10/27** |  |  |  |  |  |
| **11/3** | Etch |  | Etch | Etch | Etch |
| **11/10** | PVD |  | PVD | Andruczyk | PVD |
| **11/17** | HIDRA |  | HIDRA | HIDRA | HIDRA |
| **11/24** | Thanksgiving week |  |  |  |  |
| **12/1** | PL2 |  | PL2 |  | PL2 |