

**TO:** The Faculty of the College of Engineering  
**FROM:** School of Aeronautics and Astronautics of the College of Engineering  
**RE:** New Graduate Course, AAE 52100 Plasma Laboratory

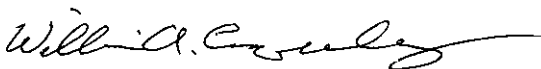
The faculty of the School of Aeronautics and Astronautics have approved the following new course. This action is now submitted to the Engineering Faculty with a recommendation for approval.

**Course no.** **AAE 52100 Plasma Laboratory**  
Spring, Lecture 1, Lab 2, Cr. 3  
Pre-req – AAE 53400 or permission of instructor

**Description:** The laboratory course will include lab prep lectures, practical classes, and mini-projects. Lab prep lectures will briefly cover topics of basic plasma physics and diagnostics relevant to the subsequent practical classes. In addition, details of the corresponding lab procedure, instructions, and lab report assignment will be discussed. Practical classes will involve students in practical creation and operation of various plasma sources and plasma diagnostics. Specifically, students will operate the DC high voltage breakdown facility, electrostatic accelerator (ion gridded thruster), cross-field accelerator (Hall thruster), Atmospheric-Pressure Plasma Jet facility, and will conduct measurements of plasma parameters using Langmuir probes, microwave interferometer, and optical spectrometer.

**Reason:** This teaching laboratory course was created to enhance the hands-on experience of students in the fields of electric propulsion, optical and microwave diagnostics, and plasma generation. Our students are being hired by government labs and the aerospace industry to do experimental work in these areas, but have very limited exposure to advanced experimental curricula. This course expands the practical skills of the students from the level of undergraduate teaching lab to the more complex environment of active experimental research lab and utilization of state-of-the-art experimental tools, techniques, and equipment.

Enrollment history: S17 (12), S18 (11), S19 (14)



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*William A. Crossley*, J. William Uhrig and Anastasia Vournas Head of the School of Aeronautics and Astronautics, and Professor of Aeronautics and Astronautics  
School of Aeronautics and Astronautics

# AAE 521 Plasma Laboratory

Spring 2020

M. 4:30-5:45 PM TBD

W. 10:30-1:20 (section 1) ARMS B107

W. 2:30-5:20 (section 2) ARMS B107

**Instructor:** Alex Shashurin  
[ashashur@purdue.edu](mailto:ashashur@purdue.edu)  
Office: ARMS 3331  
Office hours: by email appointment

**Teaching Assistant:** Yunping Zhang  
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[zhan1841@purdue.edu](mailto:zhan1841@purdue.edu)

**Texts:** *Plasma Diagnostics*, Ed. W. Lochte-Holtgreven, Amsterdam: North-Holland Publishing Company, 1968.  
or  
I.H. Hutchinson, *Principles of plasma diagnostics*, New York: Cambridge University Press, 2nd ed., 2002.

Y. P. Raizer, *Gas Discharge Physics* Springer, Berlin, 1991.

R.G. Jahn, *Physics of Electric Propulsion* New York: McGraw-Hill, 1968.

**Prerequisites:** AAE 534 Electric Propulsion or equivalent plasma course; permission of instruction

## Course description:

The laboratory course will include lab prep lectures, practical classes and mini-projects. Lab prep lectures will briefly cover topics of the basic plasma physics and diagnostics relevant to the subsequent practical classes. In addition, details of the corresponding lab procedure, instructions and lab report assignment will be discussed. Practical classes will involve students in practical creation and operation of various plasma sources and plasma diagnostics. Specifically, students will operate DC high voltage breakdown facility, electrostatic accelerator (ion thruster), cross-field accelerator (Hall thruster), Atmospheric-Pressure Plasma Jet facility, and will conduct measurements of plasma parameters using Langmuir probes, microwave interferometer and optical spectrometer.

#	Topics covered
1	<b>Fundamentals of experimental techniques:</b> Voltage and current sources, oscilloscopes and passive probes, waveform generators.
2	<b>Paschen's breakdown law:</b> Fundamentals of Townsend breakdown. Measurements of Paschen's breakdown curve in DC high voltage breakdown facility.
3	<b>Electrostatic accelerators:</b> Operation principle of ion engines. Measurements of basic discharge parameters of the accelerator. Measurements of total beam current using electrostatic probe and thrust calculations.
4	<b>Hall effect engine and thrust measurements:</b> Operation principle of cross-field accelerators. Measurements of discharge current and voltage of the Hall thruster. Indirect thrust measurements using hanging pendulum.
5	<b>Langmuir probes:</b> Fundamentals of electrostatic Langmuir probes. Measurements of plasma density and electron temperature using Langmuir probes.
6	<b>Cold plasmas and optical emission spectroscopy:</b> Operation of non-steady non-equilibrium atmospheric plasma jets (streamers). Measurements of electric properties and conducting optical emission spectroscopy measurements of excited and ionized species. Numerical simulation of second positive system of nitrogen molecule.
7	<b>Microwave interferometry:</b> Fundamentals of microwave interferometry. Constructing 10 GHz interferometer and using it to measure plasma density in glow discharge.

#### Course Website:

Course announcements, lectures etc. will be posted on the course Blackboard site.

#### Lab reports:

Lab reports will be typically due on Monday before class. Late Lab reports will be accepted within 48 hours after the due date for 90% credit. No reports will be accepted after that time. All papers must be turned in at the same time.

#### Grading Criteria:

Pre-Lab assignment: 5%

Lab report: 60%

Mini projects: 35%

#### Grading schema:

A+ ( $\geq 97$ ), A ( $\geq 93$ ), A- ( $\geq 90$ ), B+ ( $\geq 87$ ), B ( $\geq 83$ ), B- ( $\geq 80$ ), C+ ( $\geq 77$ ), C ( $\geq 73$ ), C- ( $\geq 65$ ), D ( $\geq 60$ ), F ( $< 60$ )

#### By the end of the semester, successful students will be able:

1. To operate various plasma sources including electrostatic accelerator, Hall accelerator, glow discharge and atmospheric pressure discharge.
2. To demonstrate practical skills in conducting measurements of basic electrical discharge parameters and thrust.
3. To demonstrate practical skills in conducting measurements of plasma parameters using electrostatic Langmuir probes, optical spectroscopy and microwave interferometry.

4. To demonstrate fundamental understanding of basic concepts utilized in studied plasma diagnostic techniques.
5. To demonstrate fundamental understanding of various breakdown mechanisms including Townsend and streamer breakdown.

**This syllabus is subject to change**

## **University Policies**

### **Purdue Honors Pledge**

*"As a boilermaker pursuing academic excellence, I pledge to be honest and true in all that I do. Accountable together - we are Purdue."*

<https://www.purdue.edu/provost/teachinglearning/honor-pledge.html>

### **Policy for Academic Dishonesty:**

*Purdue prohibits "dishonesty in connection with any University activity. Cheating, plagiarism, or knowingly furnishing false information to the University are examples of dishonesty." [Part 5, Section III-B-2-a, University Regulations] Furthermore, the University Senate has stipulated that "the commitment of acts of cheating, lying, and deceit in any of their diverse forms (such as the use of substitutes for taking examinations, the use of illegal cribs, plagiarism, and copying during examinations) is dishonest and must not be tolerated. Moreover, knowingly to aid and abet, directly or indirectly, other parties in committing dishonest acts is in itself dishonest." [University Senate Document 72-18, December 15, 1972]*

### **Use of Copyrighted Materials**

*Among the materials that may be protected by copyright law are the lectures, notes, and other material presented in class or as part of the course. Always assume the materials presented by an instructor are protected by copyright unless the instructor has stated otherwise. Students enrolled in, and authorized visitors to, Purdue University courses are permitted to take notes, which they may use for individual/group study or for other non-commercial purposes reasonably arising from enrollment in the course or the University generally.*

*Notes taken in class are, however, generally considered to be "derivative works" of the instructor's presentations and materials, and they are thus subject to the instructor's copyright in such presentations and materials. No individual is permitted to sell or otherwise barter notes, either to other students or to any commercial concern, for a course without the express written permission of the course instructor. To obtain permission to sell or barter notes, the individual wishing to sell or barter the notes must be registered in the course or must be an approved visitor to the class. Course instructors may choose to grant or not grant such permission at their own discretion, and may require a review of the notes prior to their being sold or bartered. If they do grant such permission, they may revoke it at any time, if they so choose.*

### **Policy for Attendance**

*Students are expected to be present for every meeting of the classes in which they are enrolled. Only the instructor can excuse a student from a course requirement or*



*responsibility. When conflicts or absences can be anticipated, such as for many University sponsored activities and religious observations, the student should inform the instructor of the situation as far in advance as possible...For unanticipated or emergency absences when advance notification to an instructor is not possible, the student should contact the instructor as soon as possible by email, or by contacting the main office that offers the course. When the student is unable to make direct contact with the instructor and is unable to leave word with the instructor's department because of circumstances beyond the student's control, and in cases of bereavement, the student or the student's representative should contact the Office of the Dean of Students,*

### **Grief Absence Policy for Students**

*Purdue University recognizes that a time of bereavement is very difficult for a student. The University therefore provides the following rights to students facing the loss of a family member through the Grief Absence Policy for Students (GAPS). GAPS Policy: Students will be excused for funeral leave and given the opportunity to earn equivalent credit and to demonstrate evidence of meeting the learning outcomes for missed assignments or assessments in the event of the death of a member of the student's family.*

### **Violent Behavior Policy**

*Purdue University is committed to providing a safe and secure campus environment for members of the university community. Purdue strives to create an educational environment for students and a work environment for employees that promote educational and career goals. Violent Behavior impedes such goals. Therefore, Violent Behavior is prohibited in or on any University Facility or while participating in any university activity.*

### **Students with Disabilities**

*Purdue University is required to respond to the needs of the students with disabilities as outlined in both the Rehabilitation Act of 1973 and the Americans with Disabilities Act of 1990 through the provision of auxiliary aids and services that allow a student with a disability to fully access and participate in the programs, services, and activities at Purdue University.*

*If you have a disability that requires special academic accommodation, please make an appointment to speak with me within the first three (3) weeks of the semester in order to discuss any adjustments. It is important that we talk about this at the beginning of the semester. It is the student's responsibility to notify the Disability Resource Center (<http://www.purdue.edu/drc>) of an impairment/condition that may require accommodations and/or classroom modifications.*

### **Emergencies**

*In the event of a major campus emergency, course requirements, deadlines and grading percentages are subject to changes that may be necessitated by a revised semester calendar or other circumstances beyond the instructor's control. Relevant changes to this course will be posted onto the course website or can be obtained by contacting the instructors or TAs via email or phone. You are expected to read your @purdue.edu email on a frequent basis.*

### **Nondiscrimination**

*Purdue University is committed to maintaining a community which recognizes and values the inherent worth and dignity of every person; fosters tolerance, sensitivity, understanding, and mutual respect among its members; and encourages each individual to strive to reach his or her own potential. In pursuit of its goal of academic excellence, the University seeks to develop and nurture diversity. The University believes that diversity among its many members strengthens the institution, stimulates creativity, promotes the exchange of ideas, and enriches campus life.*

*Purdue University prohibits discrimination against any member of the University community on the basis of race, religion, color, sex, age, national origin or ancestry, genetic information, marital status, parental status, sexual orientation, gender identity and expression, disability, or status as a veteran. The University will conduct its programs, services and activities consistent with applicable federal, state and local laws, regulations and orders and in conformance with the procedures and limitations as set forth in [Executive Memorandum No. D-1](#), which provides specific contractual rights and remedies. Any student who believes they have been discriminated against may visit [www.purdue.edu/report-hate](http://www.purdue.edu/report-hate) to submit a complaint to the Office of Institutional Equity. Information may be reported anonymously.*