PLASMAS AND FUSION

Introduction

The guidelines outlined in this document are intended to supplement the general information on graduate programs provided by Nuclear Engineering and Radiological Sciences (NERS), the College of Engineering, and the Rackham School of Graduate Studies.

Master's and Doctoral Degree Requirements

See the Rackham School of Graduate Studies Academic Policies website for graduation requirements information at: http://www.rackham.umich.edu/policies/academic_policies/. Also, see the supplementary Master's and Ph.D. Graduation Requirements and corresponding checklists for Nuclear Engineering and Radiological Sciences. All checklists should be reviewed in the term prior to graduation for the master's degree or in the term in which candidacy is achieved for the doctoral program.

Graduate Advising

Students will be assigned an advisor when they first join the graduate program. However, this assignment is tentative, and students should not be reluctant to change advisors once they have come to understand how their interests mesh with those of the various faculty members in the department. For students carrying out graduate research, the research supervisor is also their academic advisor. Before registering for a future term, the student must discuss courses with the advisor. Funding for graduate research assistants (GSRA appointments) is typically provided from research grants obtained by individual faculty members. If you decide to change advisors, the source of your support will also change, which could mean GSRA or GSI (graduate student instructor) support.

Plasmas and Fusion Research

This guide is intended for graduate students in Nuclear Engineering and Radiological Sciences who are interested in coursework and research in plasmas and fusion. The plasmas option is primarily designed for students who wish to continue training in this field through the Ph.D. level. The purpose of this document is to aid you in selecting a sequence of courses of both intermediate and long-term value. Some topics of research include:

- Aerospace plasmas related to boundary-layer dynamics and control
- Atmospheric-pressure nonthermal-plasmas for environmental and energy applications
- Compact laser-plasma radiation sources
- Computational plasma-physics
- High-intensity and high-power lasers
- High energy-density physics
- High-power microwave sources driven by long pulse, intense, relativistic, electron beams
- Inertial confinement fusion energy
- Lasers, lighting sources, displays
- Laser plasma driven particle accelerators
- Laser plasma interactions
- Multi-phase plasma interactions (e.g., liquids, aerosols, "dust")
- Plasma-assisted materials processing
- Plasma based space propulsion
- Plasma medicine, biotechnology and agriculture
- Pulsed-power science and technology
- Theoretical plasma-physics
- Z-pinch plasma science

Departmental Curriculum Guidelines

A sample course program is outlined below. It is emphasized that this is a suggested curriculum and not a set of rigid requirements. It is meant primarily as a *guide* to students and advisors during the earlier phases of the student's graduate career. Required courses to achieve Ph.D. candidacy are:

NERS 515	Nuclear Measurements Laboratory
NERS 571	Intermediate Plasma Physics I
NERS 572	Intermediate Plasma Physics II
NERS 575	Plasma Generation and Diagnostics Lab
	Graduate level mathematics

In addition, NERS 471 Introduction to Plasmas is required for students entering without undergraduate training in plasmas or fusion, subject to Advisor approval.

Sample PhD Program in Plasmas and Fusion

The following sample PhD program will enable a student to advance to candidacy and fulfill academic requirements for a PhD in Plasmas and Fusion by the end of the second winter term. Students are encouraged to design their own program of study in consultation with their graduate advisor.

1st Fall Term			**1st Winter Term**		
NERS 571*	Intermediate Plasma Physics I	3	NERS 572*	Intermediate Plasma Physics II	3
EECS 530 / PHYS 405*#	Electromagnetic Theory / Inter. Electricity & Magnetism	3	NERS 575*	Plasma Generation and Diagnostics Laboratory	4
NERS 515†	Nuclear Measurements Laboratory	4		Cognate or Breadth class †b	1-3

2nd Fall Term			**2nd Winter Term**		
NERS 990	Dissertation / Precandidate	3-4	NERS 990	Dissertation / Precandidate	3-4
	Cognate c or Breadth class †b	1-3		Cognate c or Breadth class †b	1-3
	Plasmas and Fusion class	3		Plasmas and Fusion class	3

* Required for Plasmas and Fusion Option PhD.

† Required for NERS PhD with grade of B or better.

b 6 credit hours of breadth classes required for NERS PhD

c 4 hours of cognate classes required

Counts for 3 credit hours as cognate.

Some suggested courses are listed below. Note that this is not an exhaustive list and students are encouraged to review current course listings in the College of Engineering and Graduate School bulletins and discuss with Nuclear Engineering and Radiological Sciences staff on appropriate course offerings in consultation with their advisor.

Plasmas and Fusion Classes (‡ required, [c] can count as cognate classes)	
EECS 598 [c]	Special Topics: Plasma Chemistry and Plasma Surface Interactions
EECS 598 [c]	Special Topics: Laser Plasma Diagnostics
NERS 471	Introduction to Plasmas
NERS 472	Fusion Reactor Technology
NERS 571 ‡	Intermediate Plasma Physics I
NERS 572 ‡	Intermediate Plasma Physics II
NERS 573	Plasma Engineering
NERS 574	Introduction to Computational Plasma Physics
NERS 575 ‡ (EECS 519)	Plasma Generation and Diagnostics Laboratory
NERS 576	Charged Particle Accelerators and Beams
NERS 577	Plasma Spectroscopy
NERS 578 (EECS 517)	Physical Processes in Plasmas
NERS 671	Theory of Plasma Confinement in Fusion Systems
NERS 673	Electrons and Coherent Radiation
NERS 674	High Intensity Laser-Plasma Interactions
SPACE 545 [c]	High Energy Density Physics

Supporting classes relevant to Plasmas and Fusion (all can count as cognate classes)		
AERO 523	Numerical Methods in Fluid Dynamics I	3
AERO 623	Numerical Methods in Fluid Dynamics II	3
EECS 438	Advanced Lasers and Optics Laboratory	4
EECS 503	Introduction to Numerical Electromagnetics	3
EECS 530	Electromagnetic Theory I	3
EECS 537	Classical Optics	3
EECS 539	Lasers	3
EECS 546	Ultrafast Optics	3
EECS 587	Parallel Computing	3
EECS 633	Numerical Methods in Electro-magnetics	3
EECS 634	Nonlinear Optics	3
MATH 556	Methods of Applied Mathematics I	3
MATH 557	Methods of Applied Mathematics II	3
MATH 571	Numerical Methods in Scientific Computing I	3
MATH 572	Numerical Methods in Scientific Computing II	3

MATH 671	Analysis of Numerical Methods I	3
PHYS 405	Intermediate Electricity & Magnetism	3
PHYS 406	Statistical and Thermal Physics	3
PHYS 505	Electricity and Magnetism I	3
PHYS 506	Electricity and Magnetism II	3
PHYS 510	Statistical Physics I	3
PHYS 650	Lasers and Electro-Optics I	3

Breadth Requirement Classes (6 credit hours required)

All Ph.D. students must take and obtain a grade of B (3.0/4.0 scale) or better in 6 credit hours of NERS courses selected from outside the student's option, as defined by the following lists of courses. A laboratory course used to satisfy this breadth requirement cannot be used to satisfy the laboratory requirement.

- Fission Systems and Radiation Transport: NERS 441, 543, 551, 554, 561
- Materials: NERS 521, 522, 622
- Measurements: NERS 518, 481, 580, 531, 484, 582, 583, 586, 587

Ph.D. Candidacy Exam

The written candidacy exam in the plasmas and fusion area covers the required plasma courses NERS 471, NERS 571, NERS 572, NERS 575 and electromagnetism knowledge equivalent to PHYS 405.

Primary Faculty in the Plasmas and Fusion Option and their Specialties

Low Temperature Plasmas

John E. Foster	Professor, Nuclear Engineering and Radiological Sciences
Mark J. Kushner	Professor, Nuclear Engineering and Radiological Sciences Professor, Electrical Engineering and Computer Science

High Energy Density Physics

Ronald M. Gilgenbach	Professor and Chair, Nuclear Engineering and Radiological Sciences Director, Plasma, Pulsed Power and Microwave Lab
Carolyn Kuranz	Associate Professor, Nuclear Engineering and Radiological Sciences
Y.Y. Lau	Professor, Nuclear Engineering and Radiological Sciences
Ryan D. McBride	Associate Professor, Nuclear Engineering and Radiological Sciences

High Intensity Laser-Plasma Physics

Karl M. Krushelnick	Professor, Nuclear Engineering and Radiological Sciences Professor, Electrical Engineering and Computer Science Professor, Physics Director of the Center for Ultrafast Optical Sciences
Alexander G.R. Thomas	Associate Professor, Nuclear Engineering and Radiological Sciences Associate Professor, Physics Associate Professor, Electrical Engineering and Computer Science