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Certificate of Graduate Study "Plasma Science and Engineering" Overview, Requirements, Admission Procedure

I. Introduction:

Plasma science and engineering (*PSE*) encompasses the investigation of fundamental processes in and technological applications of ionized gases. Plasmas are pervasive across an enormous scale. At one extreme plasmas constitute the matter of interplanetary space. At the other extreme plasmas are the chemically reacting media responsible for fabricating microelectronics devices. The National Research Council recently released the Decadal Study "*Plasma Science: Advancing Knowledge in the National Interest*" which discusses the anticipated science challenges in the field over the next decade. As described the report, plasma science is an essential link in the interdependent disciplines that constitute our core scientific competencies, and which contributes to many areas of national interest:

- *Economic security and prosperity*: Plasmas are essential to the manufacture of high value products. The $250 billion semiconductor industry is based upon plasma processing technologies which are necessary to make the fine features of microprocessors.
- *Healthcare*: Plasmas and charged particle transport are emerging forces in healthcare. A new field of low temperature plasmas is the use of ionized gases in the treatment of tissue and sterilization. Plasma based particle accelerators are already poised to provide table-top x-ray sources for both radiotherapy and radiography.
- *Energy and environmental security:* The future well being of the world relies on the availability sustainable energy sources and environmentally benign technologies. Plasmas are at the heart of both goals. For example, fusion will produce electricity from the energy released by carbon-free reactions fusing hydrogen nuclei together in plasmas. The majority of renewable energy technologies, such as solar cells, rely on plasma fabrication processes.
- *National security*: Plasma science is at the heart of national security through its contributions to stewardship of nuclear technologies and defensive systems. Research on High Energy Density plasmas advances the fundamental science required for many of these missions, with additional extensive applications to astrophysics, to the development of particle and photon sources for science and medicine, and to advanced manufacturing methods.
- *Scientific discovery:* Perhaps most importantly, *PSE* lies at the heart of scientific discovery. Dark matter aside, the vast majority of the known universe is in the plasma state. The most basic and most extreme processes in interstellar space, nebula, cosmic x-ray sources and the near space environment surrounding the earth are plasma based. Simply getting spacecraft to the outer planets to make observations often requires plasma propulsion systems.

PSE is by any measure an interdisciplinary field and so students pursuing graduate study in topics related to *PSE* may be enrolled in any one of a dozen departments. Their common intellectual thread is the study of fundamental plasma processes which are then applied to the investigation of natural phenomena and society benefiting technologies. This common intellectual thread is addressed by the *Certificate of Graduate Study in Plasma Science and Engineering* (*GPSE*). The *GPSE* accentuates the linkages between these diverse approaches to *PSE* and so broadens the students' graduate experiences.

II. Requirements for the Graduate Certificate in PSE

The requirements for the *Graduate Certificate in Plasma Science and Engineering* are as follows.

1. Coursework in the fundamentals and applications of *PSE*. *(Required)*

   14 Graduate Credit Hours are required for the *GPSE*. Since the students entering the *GPSE* are from many different departments and have quite varied backgrounds, specific courses will not be required. Instead, a course of study will be proposed by the student and his/her advisor(s) for discussion and approval by the *GPSE* Program Committee. The *GPSE* approved list of courses appears below. Other courses may be approved by request. The recommended breadth requirements are:

   - 1 course in plasma fundamentals
   - 1 course in plasma technology
   - 1 laboratory course
   - 1 course in supporting sciences

2. Of the 14 hours required, 2 courses (or 5 hours) may be doubled counted from another Rackham graduate degree. This double counting should be consistent with Rackham requirements that at most 1/6 of the credits for a graduate degree can be double counted.

3. The laboratory requirement may be satisfied by an appropriate extramural research experience (e.g., internship at a national laboratory, company or collaborating university) that has a substantial laboratory component. Approval must be obtained by petition from the GPSE Program Committee.

4. Research on a topic closely related to *PSE*. *(Required)* This option may be met in one of two ways:

   - Completion of a PhD thesis on a topic closely related to *PSE*. The appropriateness of the thesis topic will be approved by the *GPSE* Program Committee.

   or

   - Completion of at least a 1-semester research project on a topic approved by the *GPSE* Program Committee. The course credits for the research project may count towards the 15 required for the certificate.

5. Participation in the *GPSE* Annual Research Symposium on at least one occasion to report on the results of *PSE* related thesis research or a *PSE* related research project. *(Required)*

   The Annual Research Symposium will provide graduate students with an opportunity to present the results of their research in talks and poster sessions, and interact with *GPSE* faculty and students.

III. Admission to the Graduate Certificate in PSE

Students applying for admission to the GPSE must be enrolled in a graduate degree-granting program at the University of Michigan. Admission to the GPSE may be granted at any time. The admission procedure is:

1. Submit application form obtained from the MIPSE Website (http://mipse.umich.edu/graduate_certificate.htm). (Send to mjkush@umich.edu.)
2. Letter of support from current advisor. (Send to mjkush@umich.edu.)
3. If the student is currently in a Rackham graduate program, submit the form *Dual Degree/Program Application* obtained from: http://www.rackham.umich.edu/downloads/admissions/forms/DualDegreeProgram.pdf
   The PSE program code is 01977.

***Table I* – Approved Courses for the**
Graduate Certificate in Plasma Science and Engineering

Rubric	Course Title	Funda-mental	Techno logy	Lab	Support ing
AEROSP 335	Aircraft and Spacecraft Propul-sion		X		
AEROSP 532	Molecular Gas Dynamics				X
AEROSP 533 (EN-SCEN 533).	Combustion Processes				X
AEROSP 536	Electric Propulsion	X	X		
Astronomy 160	Introduction to Astrophysics.				X (See Note 1)
Astronomy 531	Stellar Astrophysics				X
AOSS 101	Introduction to Rocket Science				X (See Note 1)
AOSS 370	Solar Terrestrial Relations	X (See Note 1)			
AOSS 450	Geophysical Electromagnetics	X			
AOSS 477	Space Weather Modeling	X			
AOSS 495	Upper Atmosphere and Iono-sphere				
AOSS 545	High Energy Density Physics	X	X		
AOSS 564 (AEROSP 564)	Introduction to the Space and Spacecraft Environment	X	X		
AOSS 595 (EECS 518)	Magnetosphere and Solar Wind	X			
AOSS 597 (AEROSP 597)	Fundamentals of Space Plasma Physics	X			
AOSS 595	- Magnetosphere and Solar Wind	X			
AOSS 598	Sun and Heliosphere	X			
EECS 423	Solid-State Device Laboratory		X	X	
EECS 425	Integrated Microsystems Labora-tory		X	X	
EECS 430 (AOSS 431)	Radiowave Propagation and Link Design				X
EECS 503	Introduction to Numerical Elec-tromagnetics				X
EECS 530 (APPPHYS 530)	Electromagnetic Theory I				X
EECS 517 (NERS 578)	Physical Processes in Plasmas	X	X		
EECS 528	Principles of Microelectronics Process Technology		X		
EECS 587	Parallel Computing				X
EECS 633	Numerical Methods in Electro-magnetics				X
EECS 720	Special Topics in Solid-State De-vices, Integrated Circuits, and Physical Electronics	X	X		
ME 586 (Mfg 591).	Laser Materials Processing		X		

MATH 571	Numerical Methods for Scientific Computing I				X
MATH 572	Numerical Methods for Scientific Computing II				X
MSE 489	Materials Processing Design			X	X
NERS 425.	Application of Radiation		X		
NERS 471.	Introduction to Plasmas	X			
NERS 472.	Fusion Reactor Technology		X		
NERS 571.	Intermediate Plasma Physics I	X			
NERS 572. (Appl Phys 672)	Intermediate Plasma Physics II	X			
NERS 575 (EECS 519)	Plasma Generation and Diagnostics Laboratory		X	X	
NERS 576.	Charged Particle Accelerators and Beams	X	X		
NERS 577.	Plasma Spectroscopy	X			
NERS 578 (EECS 517)	Physical Processes in Plasmas	X	X		
NERS 590-002	Plasma Engineering	X	X		
NERS 590-003	Computational Plasma Physics	X	X		
NERS 671.	Theory of Plasma Confinement in Fusion Systems I	X			
NERS 672.	Theory of Plasma Confinement in Fusion Systems II	X			
NERS 673.	Electrons and Coherent Radiation	X			
NERS 674 (Appl Phys 674).	High Intensity Laser-Plasma Interactions	X			
PHYSICS 405	Intermediate Electricity and Magnetism				X
PHYSICS 406	Statistical and Thermal Physics				X
PHYSICS 505	Electricity and Magnetism I				X
PHYSICS 506	Electricity and Magnetism II				X
PHYSICS 510	Statistical Physics I				X

Notes: 1. This course is of general interest for plasmas but does not count towards the 14 credits required for the GPSE.