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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 Decadal Study "*Plasma Science: Advancing Knowledge in the National Interest*" discussed 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. For example, 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, 1 courses (or 3 hours) may be doubled counted from another Rackham graduate degree. This double counting is 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 14 credits 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:// http://mipse.umich.edu/certificate.php). (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/students/navigate-degree/dual-joint-degree-programs
   http://www.rackham.umich.edu/downloads/oard-dual-joint-6010-election-form.pdf
   The PSE program code is 01977.

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

Rubric	Course Title	Fundamental	Technology	Lab	Supporting
Aerospace Engineering					
AEROSP 335	Aircraft and Spacecraft Propulsion		X (See Note 1)		
AEROSP 523	Computational Fluid Dynamics				X
AEROSP 532	Molecular Gas Dynamics				X
AEROSP 533 (ENSCEN 533)	Combustion Processes				X
AEROSP 536	Electric Propulsion	X	X		
Astronomy					
Astronomy 160	Introduction to Astrophysics				X (See Note 1)
Astronomy 530	Stellar Astrophysics				X
Climate and Space Sciences					
SPACE 101	Rocket Science				X (See Note 1)
SPACE 370 (EARTH 370)	Solar Terrestrial Relations	X (See Note 1)			
CLIMATE 450 (SPACE 450)	Geophysical Electromagnetics	X			
SPACE 477	Space Weather Modeling	X			
CLIMATE 479 (ENSCEN 533)	Atmospheric Chemistry				X
SPACE 495 (ENSCEN 495)	Upper Atmosphere and Ionosphere				
SPACE 545	High Energy Density Physics	X	X		
SPACE 564 (CLIMATE 564)	Stratosphere and Mesophere				X
SPACE 565 (CLIMATE 565)	Planetary Science				X
CLIMATE 567	Chemical Kinetics				X
CLIMATE 574 (AEROSP 574)	Introduction to Space Physics	X	X		
SPACE 595 (EECS 518)	Magnetosphere and Solar Wind	X			
SPACE 597 (AEROSP 597)	Fundamentals of Space Plasma Physics	X			
SPACE 598	Sun and Heliosphere	X			
Electrical Engr. & Computer Science					
EECS 423	Solid-State Device Laboratory		X	X	
EECS 425	Integrated Microsystems Laboratory		X	X	

EECS 430 (SPACE 431)	Radiowave Propagation and Link Design				X
EECS 503	Introduction to Numerical Electromagnetics				X
EECS 517 (NERS 578)	Physical Processes in Plasmas	X	X		
EECS 530 (APPPHYS 530)	Electromagnetic Theory I				X
EECS 539 (APPPHYS 551) (PHYSICS 651)	Lasers				X
EECS 528	Principles of Microelectronics Process Technology		X		
EECS 587	Parallel Computing				X
EECS 598	Plasma Chemistry and Plasma Surface Interactions	X			
EECS 633	Numerical Methods in Electromagnetics				X
Mechanical Engineering					
ME 523	Computational Fluid Mechanics				X
ME 586	Laser Materials Processing		X		
Mathematics					
MATH 571	Numerical Methods for Scientific Computing I				X
MATH 572	Numerical Methods for Scientific Computing II				X
Materials Science and Engineering					
MSE 489	Materials Processing Design			X	X
Nuclear Engineering & Radiological Sciences.					
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 (APPPHY 672)	Intermediate Plasma Physics II	X			
NERS 573	Plasma Engineering	X	X		
NERS 574	Introduction to Computational Plasma Physics	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 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 (APPPHY 674)	High Intensity Laser-Plasma Interactions	X			
Physics					
PHY 405	Intermediate Electricity and Magnetism				X
PHY 406	Statistical and Thermal Physics				X
PHY 505	Electricity and Magnetism I				X
PHY 506	Electricity and Magnetism II				X
PHY 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.