

PENNSSTATE



DEPARTMENT OF AEROSPACE ENGINEERING

Guide to Graduate Studies

2013 / 2014

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PREFACE

This Guide to Graduate Study provides information about the graduate degree program in the Aerospace Engineering Department of the Pennsylvania State University. It is intended to serve as an introduction to the program for new graduate students and as a reference resource for continuing graduate students, faculty, and staff of the department. It is designed to supplement the Graduate Degree Programs Bulletin (henceforth referred to as “the Bulletin”), issued by the Graduate School, which is the primary reference document for graduate study at Penn State. Inquiries about the Bulletin and its contents should be addressed to:

Graduate Enrollment Services (GES)
The Pennsylvania State University
114 Kern Graduate Building
University Park, PA 16802
Phone: (814) 865-1795
<http://www.gradsch.psu.edu>

A brief overview of Penn State University, the Graduate School, the College of Engineering, and the Department of Aerospace Engineering is provided in the Introduction.

The Aerospace Graduate Program and Academic Requirements and Guidelines are next discussed in Sections II and III, respectively. Section IV presents the faculty and laboratory staff of the department. Any questions regarding the Aerospace Graduate program should be addressed to:

Ms. Nancy C. Nagle
Graduate Program Staff Assistant
Department of Aerospace Engineering
The Pennsylvania State University
229 Hammond Building
University Park, PA 16802
Phone: (814) 865-6431
Fax: (814) 865-7092
ncn2@psu.edu

Additional sources of useful information for graduate students may be obtained by contacting:

University Office of Global Programs
The Pennsylvania State University
410 Boucke Building
University Park, PA 16802
Phone: (814) 865-6348
Fax: (814) 865-6480
<http://www.international.psu.edu>

Student Affairs Off-Campus Living
The Pennsylvania State University
125 HUB-Robeson Center
University Park, PA 16802
Phone: (814) 865-2346
email: ldr5@sa.psu.edu
<http://www.sa.psu.edu/ocl>

Student Health Insurance Office
The Pennsylvania State University
302 Student Health Center
University Park, PA 16802
(814) 865-7467
Fax: (814) 863-1390
Email: studentinsurance@sa.psu.edu
<http://www.sa.psu.edu/uhs/basics/insurance.cfm>

Office of Disability Services
116 Boucke Building
University Park, PA 16802-5902
Phone: (814) 863-1807 (Voice or TTY)
Fax: (814) 863-3217
<http://www.equity.psu.edu/ods/>

To the incoming graduate students of the Department, I welcome you all on behalf of the Department of Aerospace Engineering and wish you success in your studies.

Michael M. Micci
Professor and Director of Graduate Studies
Phone: (814) 863-0043
micci@psu.edu

INTRODUCTION

The University and Graduate School

The Pennsylvania State University (<http://www.psu.edu>) is a land-grant University serving the Commonwealth of Pennsylvania from a number of campuses located throughout the State. The central campus, located at University Park, offers undergraduate and graduate education and research through its Colleges of Agricultural Sciences, Arts and Architecture, Business, Earth and Mineral Sciences, Education, Engineering, Health and Human Development, Information Science and Technology, Liberal Arts, Science, and the School of Communications.

The Graduate School (<http://www.gradsch.psu.edu>) administers for the University all graduate programs in the various Colleges and Schools. Among other functions, it provides a common admission process for all graduate programs and administers a number of graduate fellowship programs.

The College of Engineering

Aerospace Engineering is a department within the College of Engineering (<http://www.engr.psu.edu>) which is also home for 18 other departments and a number of specialty programs and research units. The Associate Dean for Graduate Studies and Research provides a liaison between the graduate programs within the college and the Graduate School and external research sponsoring organizations. A number of College of Engineering Fellowships are also administered from the Dean's Office.

The Aerospace Engineering Department

The Department (<http://www.aero.psu.edu>) provides undergraduate and graduate educational programs in all the major disciplines of aerospace sciences: aerodynamics, structures, guidance, dynamics and control, and propulsion. It promotes and supports vigorous research by its faculty members with assistance from graduate students, and maintains a number of experimental and computational research facilities.

It is administered by the Department Head (Prof. George A. Lesieutre), Administrative Assistant (Ms. Sheila Corl), clerical staff, and faculty directors of undergraduate and graduate studies and admission. The Director of Graduate Studies (Michael M. Micci) is responsible for the admission of new graduate students into the graduate program, the graduate courses, and Doctoral Candidacy Examination. He is assisted by the Graduate Program Staff Assistant (Ms. Nancy C. Nagle).

Graduate programs lead to the Master of Science (M.S.), Master of Engineering (M.Eng.), or Doctor of Philosophy (Ph.D.) degrees.

Expenses and Financial Aid

General Expenses

For the latest information concerning tuition rates, room and board rates, bill due dates, payment plan, refund policy, residency policy, retroactive registration, tuition bill instructions, tax credits, and tuition adjustments please go to <http://www.bursar.psu.edu>.

Medical Insurance (<http://www.sa.psu.edu/uhs/currentstudents/gains.cfm>)

The University **requires medical insurance** for all students enrolled at Penn State and their accompanying dependents (spouse and/or children). As a Graduate Assistant or Graduate Fellow, you are eligible to receive subsidies in the amount of 80% of the annual premium cost for the Graduate Assistant and Graduate Fellow Insurance Plans. The university will pay this amount directly to the insurance companies and will deduct your 20% contribution to premium expense from your monthly paycheck.

Your insurance subsidies for your eligible dependents are 70% of the annual premium expense. As with the subsidy for your individual insurances, the university will pay 70% of the premium expense directly to the insurance companies and you will pay your 30% of the premium costs through a payroll deduction.

Penn State will not supplement, nor will a payroll deduction be made for medical insurance policies other than the Penn State Graduate Assistant Graduate Fellow Plan.

Please contact the Student Insurance Office at 208 Boucke Building, University Park, or call 814-865-7467 or visit <http://studentaffairs.psu.edu/health/services/insurance> for additional information.

Penn State students are eligible to purchase a student health insurance plan for the upcoming academic year. All graduate students taking one or more credits are eligible to purchase the plan. The plan is offered online through [Aetna Student Health Insurance](#).

Overview

The Student Health Insurance office is responsible for administering the health insurance plan for Penn State students:

- The [Graduate Assistant & Graduate Fellow Insurance](#), which is available as a benefit to Graduate Assistants and Graduate Fellow.
- [This site](#) will allow you to decline the automatic medical, dental and vision coverage provided to Graduate Assistants/Graduate Fellows (GA/GF) and/or allow you to add dependents to the medical, dental and vision coverage. This process needs to be completed every fall semester since the GA/GF benefits are reset to Single Student Coverage each Fall Semester.
- The [Penn State Student Health Insurance Plan](#), which is available to undergraduate and graduate students:
 - who have no health insurance coverage;
 - who need supplemental insurance because their current plan does not provide adequate coverage while they are at Penn State.
 - who are international students and must comply with [Penn State's Mandatory Health Insurance Requirement](#)

Please contact the Student Insurance Office at 208 Boucke Building, University Park, or call 814-865-7467 or visit <http://studentaffairs.psu.edu/health/services/insurance> for additional information.

Financial Aid

Many opportunities exist for financial support. There are graduate assistantships, fellowships and traineeships, graduate school tuition assistance (for summer semester) and employment and loan programs available through the Office of Student Aid.

Half-time teaching and research assistantships are available within the department on a competitive basis, carrying a stipend plus paid tuition. The student on a half-time assistantship normally schedules **12 credits per semester** and performs tasks that, on average, occupy approximately 20 hours per week. For M.S. or M.Eng. degree candidates working as teaching assistants, the duration of this support is typically two years, without tuition in the fourth semester. Most research assistantships are also available during the summer, offering an additional stipend. Nearly all assistantships are half-time, however, quarter-time or three-quarter time assistantships may be arranged for special needs.

TAs, RAs & TAides

There are two main types of graduate assistantships at Penn State, Teaching assistantships (TA) and Research Assistantships (RA). The financial support for RAs is usually provided by external grants made to individual faculty members. TAs are controlled by the department.

TA responsibilities typically include grading, running lab sections, holding office hours and problem sessions, and occasional lecturing. TA positions do not usually include summer support. The Department of Aerospace Engineering frequently supports M.S. and M. Eng. students as TAs for three (3) semesters because students usually complete the bulk of coursework in three semesters, followed by one (1) semester of support as a Teaching Aide (TAide). The Teaching Aide is a wage payroll position which provides students with support equivalent to that of the TA stipend and **does not include** tuition remission or insurance coverage.

TAs actually teaching (i.e. lab course 305W) should take ENGR 588 (1 cr.) this semester. The remaining TAs should take the Grader's Seminar. Please see the Graduate Program Staff Assistant for more details and registration.

Foreign nationals are required to take the oral language SPEAK test (formerly Test of Spoken English) if they are serving as a TA/TAide (results for this semester were given to the students involved). Please see the Director of Graduate Studies to discuss results.

TAs & TAides are evaluated by supervising instructor at end of each semester. This information is used by the Director of Graduate Studies & the Department Head for making future selections.

RA activities typically include literature review, problem definition, analysis, experiments, report writing, and presentations. A report of this research work and its results will likely constitute the bulk of your thesis. RA positions usually include summer support, at an hourly rate comparable to that of the academic year stipend. To inquire about the possibility of an RA, you should contact faculty members who are performing research of interest to you.

TAs & RAs should register for the maximum number of 12 credits (including thesis research, AERSP 600).

Students may want to apply for the Tuition Assistance Program in the Summer Session to maximize tuition monies. Ph.D. students should request Summer assistance if they plan to take Comprehensive Examination or Final Defense of Thesis. Faculty and students will be informed of application dates.

TA and RA monthly stipends will be deposited into personal bank accounts on the last working day of each month.

TAides and RAides

Students will be paid via wage payroll, on a bi-weekly pay schedule, and will be responsible for their tuition and health insurance expenses. Timesheets reporting hours worked should be promptly submitted to the bookkeeping office to ensure timely payment.



The GRADUATE SCHOOL

DATE: February 22, 2006

TO: Graduate Program Chairs, Staff Assistants, Faculty and Graduate Students

FROM: Regina Vasilatos-Younken, Senior Associate Dean

SUBJECT: Discontinuation of "Tax Letters"

Each year, as the time for filing tax returns approaches, questions arise regarding how assistantships and fellowships are treated in terms of tax liability, reporting obligations, etc. Keeping in mind the overriding advice that graduate students, as anyone, should seek the advice of a qualified tax consultant, the following information may be helpful in clarifying how the University handles these different financial entities and the basis for why these differ. Please feel free to share this information with graduate students, faculty and other program personnel who advise your students.

A fellowship recipient is not a University employee. Accordingly, the University has no obligation to (and does not) withhold tax on fellowship awards, or report these awards to Federal (IRS), state or local taxing authorities. Because fellowship amounts are not reported to taxing authorities, nor have taxes been withheld, units have no reason to complete "Tax Letters" for fellowship recipients as they may have in the past for graduate assistants (GAs). Therefore, the University no longer permits the issuance of Tax Letters. Please note that even though the University does not report on or withhold tax from fellowships, recipients may be liable for taxes on any amount of such awards not used for payment of tuition, fees or other qualified education expenses. In order to assist fellowship recipients with their tax returns, the Payroll Office reports to them the amount of their fellowship payments received during the year. However, as indicated above, taxes are not withheld nor are Fellowship amounts reported, and therefore the University no longer permits the issuance of Tax Letters.

Alternatively, GA stipends are wages for federal tax purposes and subject to tax reporting and withholding. However, for PA state and local tax purposes, GA stipends are only taxable when the GA must perform duties beyond those required of all degree candidates in their program. In the past, Tax Letters were prepared for GAs, in order to assist them in obtaining a refund of PA taxes withheld on their GA stipend, given that the University treated all GA stipends as subject to PA tax. Now, PA tax is correctly not withheld on non-taxable GA stipends (i.e., when the GA performs no services beyond those required of all other students in the program, as indicated in the GA appointment form). Thus, the University no longer has reason to issue Tax Letters, given that the appropriate PA tax withholding is applied to each GA paycheck. Therefore, as indicated above, the University no longer permits the issuance of Tax Letters.

International Taxes:

Federal regulations mandate withholding International Taxes for foreign students who receive any assistance in excess of tuition and fees. The Student Loans & Scholarships Office is responsible for withholding these taxes. The tax rate is 14%. As an example:

Tuition + Fees:	\$5,000
Tuition Provided by Asst/Fellowship:	\$4,790 (Tuition portion only. Stipends are processed through Payroll)
Additional Scholarships:	\$1,000.00
Amount Subject to International Taxes:	$(\$4790.00 + \$1,000.00) - (\$5,000) = \790.00
Tax Liability:	$\$790 \times 14\% = \110.60

However, foreign students from certain countries may qualify for an exemption to this withholding if they are citizens of a country that have a tax treaty with the United States, complete form W-8BEN and submit it to the Student Loans & Scholarships Office. For further information, please refer your students to:

<http://www.studentloans.psu.edu/tax.cfm>

Again, to determine an individual graduate student's tax liability, he/she should consult a qualified tax consultant; however, the above may be helpful in providing some guidance and clarifications. For any questions related to the above, please contact the Office of Graduate Fellowships and Awards Administration; 313 Kern Graduate Building; 863-2514.

SLC-0502

DATE: January 20, 2005
FROM: Sheila Corl, Administrative Assistant
TO: Deans L. C. Burton & J. M. Mason
SUBJ: Criteria for PA & Local Tax Exemption Status for Graduate Assistantships

Per the request of 1/17/05, listed below are the criteria for which the Department of Aerospace Engineering determines those graduate assistants who are eligible for the state and local tax exemption status.

“It is the expectation of the University as well as the Department of Aerospace Engineering that all MS and PhD degree candidates, as part of their responsibilities (in addition to taking courses), conduct independent research enabling them to prepare a thesis, which is required of all students to meet requirements as specified in the PSU Graduate Degree Programs Bulletin. The work performed by a **GRADUATE RESEARCH ASSISTANT** involves only research that forms the core of the requirement for the degree, and the same type of research is conducted by all MS or PhD candidates, whether or not they receive support for their efforts.”

“**GRADUATE TEACHING ASSISTANTS** are providing a **service** to the Department and University, which is **not** a requirement of all graduate students.”

slc
Cc: G. A. Lesieutre
D. B. Spencer
R.I. Grandy
D.J. Witherite
J. G. Shawver

Departmental Student Organizations

American Institute of Aeronautics and Astronautics (AIAA) (<http://www.aiaa.org>)

The AIAA is the largest American technical society devoted to science and engineering in the fields of space, technology, rocket systems, aerodynamics, and marine systems. Students are encouraged to join the Penn State Student Branch of the AIAA. Membership applications and information on the benefits of belonging to this organization may be obtained from the AIAA faculty advisor. Meetings and social events (including a picnic) are held regularly during the academic year. Members can also attend the annual student conference for the Mid-Atlantic Region each April. Listen for announcements in class and watch the Aerospace bulletin board for notices. Dr. Robert G. Melton, 229B Hammond, is the faculty advisor to the PSU Student Branch of the AIAA.

American Helicopter Society (AHS) (<http://www.vtol.org/>)

The American Helicopter Society student chapter is the Department's newest organization, having received its charter from the parent organization in July 1980. Our AHS student chapter is now one of the largest and most active chapters in the country. If you are interested in joining the AHS, please watch the Aerospace bulletin board for meeting notices or contact Dr. Edward C. Smith, the faculty advisor to the PSU student branch. Dr. Smith's office is in Room 231D Hammond Building.

Aerospace Graduate Student Association (AeroGSA)

As an organization, AeroGSA plays a number of important roles within the Department of Aerospace Engineering at Penn State:

- AeroGSA provides a means of communication between graduate students and the faculty and administration of the department. In previous years, this communication has been instrumental in improving the environment for graduate students within the department.
- AeroGSA provides social opportunities such as IM sports teams, movies, mixers, and other activities. It enables students from different parts of the department (and world!) who might not interact much in the normal course of events to get to know one another better.
- AeroGSA provides service to the graduate student population and the department at large. In previous years, AeroGSA has assisted with the graduate open house in the spring, and with new student orientation in the fall. There are great opportunities in AeroGSA for students who care about making a difference.

Contact one of the AeroGSA Officers to find out how you can get involved. The faculty advisor is Dr. Michael M. Micci.

Engineering Graduate Student Council (EGSC) (<http://www.engr.psu.edu/egsc/>)

The Penn State Engineering Graduate Student Council (EGSC) strives to promote and enhance graduate studies in the College of Engineering by providing a forum for open discussion and by serving as a communication link between students, faculty, and administrators within the College. EGSC is comprised of representatives from each of the 15 Engineering Departments. AeroGSA selects a representative to the EGSC.

LIST OF AEROSPACE FACULTY

<u>Name</u>	<u>Title</u>	<u>Office</u>	<u>Phone</u>	<u>E-Mail</u>
Dr. Kenneth S. Brentner	Professor	233D Hammond	865-6433	ksbrentner@psu.edu
Dr. Cengiz Camci	Professor	233 Hammond	865-9871	c-camci@psu.edu
Dr. Stephen Conlon	Associate Professor	165 ARL	863-3027	scc135@psu.edu
Dr. Joseph F. Horn	Associate Professor	231C Hammond	865-6434	joehorn@psu.edu
Dr. Robert F. Kunz	Professor	165 ARL	865-2144	rfk102@psu.edu
Dr. Jacob "Jack" Langelaan	Associate Professor	233G Hammond	863-6817	jwl16@psu.edu
Dr. George A. Lesieutre	Professor & Department Head	225A Hammond	863-0103	g-lesieutre@psu.edu
Dr. Deborah A. Levin	Professor	233E Hammond	865-6435	dalevin@psu.edu
Dr. Geoffrey Lilley	Adjunct Professor U. of Southampton	NASA Langley		
Dr. Lyle N. Long	Distinguished Professor	229C Hammond	865-1172	lnl@psu.edu
Dr. Mark D. Maughmer	Professor	233F Hammond	863-4485	mdm@psu.edu
Dr. Barnes W. McCormick	Boeing Professor Emeritus	232B Hammond	863-0602	bwmaer@engr.psu.edu
Dr. Dennis K. McLaughlin	Professor	230A Hammond	865-2560	dkm2@psu.edu
Dr. Robert G. Melton	Professor & Director of Undergraduate Studies	229B Hammond	865-1185	rgmelton@psu.edu
Dr. Michael M. Micci	On Sabbatical - 2013/2014 Professor & Director of Graduate Studies	230C Hammond	863-0043	micci@psu.edu
Dr. Philip J. Morris	Boeing / A.D. Welliver Professor	233C Hammond	863-0157	pjm@psu.edu
Dr. Jose L. Palacios	Assistant Professor	233H Hammond	867-4871	jlp324@psu.edu
Dr. Sven Schmitz	Assistant Professor	232A Hammond	863-0778	sus52@psu.edu
Dr. Edward C. Smith	Professor	231D Hammond	863-0966	ecs5@psu.edu
Dr. Hubert C. Smith	Associate Professor Emeritus	224 Hammond	865-7783	hcsaer@engr.psu.edu
Dr. David B. Spencer	Professor & Interim Director of Graduate Studies	229A Hammond	865-4537	dbs9@psu.edu
Dr. Susan Stewart	Research Associate	230B Hammond	863-0138	sstewart@psu.edu

LABORATORY STAFF

<u>Name</u>	<u>Title</u>	<u>Room</u>	<u>Phone</u>	<u>E-mail</u>
Mr. Richard R. Auhl	Laboratory Director and Instructor	226 Hammond	865-5381	rraer@engr.psu.edu
Mr. Mark S. Catalano	IT Manager	226 Hammond	865-5703	mac9@psu.edu
Mr. Kirk Heller	Systems Administrator	48 Hammond	865-5703	akh123@psu.edu
Mr. Jeffrey Friday	IT Specialist	48 Hammond	865-5703	jwfl6@psu.edu

LIST OF AEROSPACE STAFF

<u>Name</u>	<u>Title</u>	<u>Room</u>	<u>Phone</u>	<u>E-Mail</u>
Ms. Jane Auhl	Software Systems Assistant	222 Hammond	863-6349	jea5@psu.edu
Ms. Debby Mayes	Department Head Staff Assistant	225A Hammond	863-0065	dvm3@psu.edu
Ms. Tammy Besecker	Part-Time Administrative Assistant	222 Hammond	863-6357	tdb1@psu.edu
Ms. Sheila Corl	Administrative Assistant	227A Hammond	865-6997	sxi1@psu.edu
Ms. Amy Custer	Undergraduate Program Staff Assistant	225 Hammond	865-6432	asm1@engr.psu.edu
Ms. Brenda Kasubick	Bookkeeper (Petty cash, purchases, wage-payroll, travel)	227 Hammond	863-1077	bmk16@psu.edu
Ms. Nancy Nagle	Graduate Program Staff Assistant	229 Hammond	865-6431	ncn2@psu.edu
Ms. Debbie Mottin	Staff Assistant for ICS & Vertical Lift Rotorcraft Centers of Excellence	233B Hammond	865-1966	daj122@psu.edu
Ms. Michelle Barnyak	Department Staff Assistant	229 Hammond	863-6361	mlf1@psu.edu
Ms. Debbie Boyle	Accounting Clerk (Keys, assistantships)	227B Hammond	865-1043	dub6@psu.edu
Ms. Elaine Gustus	Instructional Designer	231A Hammond	863-7457	etg10@engr.psu.edu

Graduate Student Resource Guide

University Office of Global Programs provides answers to questions and needs that are unique to international students. The office is located at 410 Boucke Building. <http://www.international.psu.edu/>

Graduate Student Association (GSA) is the representative body for all graduate students. The GSA addresses issues of concern to graduate students and elects members to sit on shared-governance bodies of the University. The GSA also organizes social events for graduate students. <http://www.clubs.psu.edu/up/gsa/>

The Office of Student Aid is a good place to begin the search for financial assistance. <http://www.psu.edu/studentaid/>

The Office for Disability Services provides information and assistance to students with disabilities. <http://www.equity.psu.edu/ods/>

The Writing Center is sponsored by the Graduate School and provides assistance to graduate students who wish to enhance their writing skills. Graduate students are invited to schedule appointments for one-on-one discussions of their writing projects. <http://www.psu.edu/dept/cew/GWC.shtml>

Penn State Escort Service is operated under the auspices of Police Services and will provide an escort for students walking on campus after dark. The escort service may be reached at 5-WALK (865-9255). <http://www.psu.edu/dept/police/escortservice.html>

Off-Campus Housing opportunities are listed in 213 HUB-Robeson Center, 865-2346. <http://www.sa.psu.edu/ocl/>

Office of Judicial Affairs is responsible for dealing with violations of the Code of Conduct including sexual assault, harassing, stalking, and physical assault. The phone number is 863-0342. <http://www.sa.psu.edu/ja/>

The Code of Conduct is available at <http://www.sa.psu.edu/ja/conduct.shtml>

The Affirmative Action Office is committed to ensuring the University maintains an environment free of harassment and discrimination. <http://www.psu.edu/dept/aaoffice/>

HUB-Robeson Center is the site for multiple student services including restaurants, a copy center, a bank (Penn State Federal Credit Union), STA Travel, a convenience store, the Penn State Bookstore, the Center for Arts and Crafts, Art Galleries, and the main information desk for the University. <http://www.sa.psu.edu/usa/hub/>

Counseling and Psychological Services (CAPS) can help students resolve personal concerns that may interfere with their academic progress, social development, and satisfaction at Penn State. Some of the more common concerns include difficulty with friends, roommates, or family members; depression and anxiety; sexual identity; lack of motivation or difficulty relaxing, concentrating or studying; eating disorders; sexual assault and sexual abuse recovery; and uncertainties about personal values and beliefs. <http://www.sa.psu.edu/caps/>

University Police and Public Safety - Penn State is committed to assisting all members of our community in providing for their own safety and security. The annual security and fire safety compliance document is available on the University Police and Public Safety website at: <http://www.police.psu.edu/cleryact/>

Career Services, located in the MBNA Career Services Building, is fully equipped to assist graduate students in the preparation of resumes and curriculum vitae and in developing effective interviewing skills. Career Services hosts a career fair that is open to graduate as well as undergraduate students.

<http://www.sa.psu.edu/career/>

Research Protections is the office that oversees all research on human participants, animals, radioisotopes and biohazardous materials. You must have permission from this office prior to conducting research involving any of these subjects. Permission cannot be obtained after the work has begun.

<http://www.research.psu.edu/orp/>

Pasquerilla Spiritual Center is home to more than fifty spiritual organizations. The center is non-denominational and provides students with opportunities to explore ethical and spiritual issues.

<http://www.sa.psu.edu/insights/jan04/spiritual.shtml>

Problem resolution

Graduate students occasionally have difficulties with their advisors, their programs or an academic matter associated with their programs. The first step in problem resolution is always to talk with your advisor and then with the program chair or department head and then the associate dean of your college. If satisfactory resolution remains elusive, the associate dean of the Graduate School is available to provide guidance and maintain neutrality. Issues discussed during meetings with the assistant dean will remain confidential if requested by the student. Appointments may be made by calling 865-2516.

Academic Integrity

The University does not tolerate violations of academic integrity, which include but are not limited to: plagiarism, cheating, falsification of information, misrepresentation or deception. The complete policy is available at:

<http://www.psu.edu/dept/ufs/policies/47-00.html#49-20>

Plagiarism

Plagiarism is often a confusing concept. At Penn State, plagiarism means taking someone's words and presenting them as your own. Cutting and pasting from a web site is considered plagiarism. Copying verbatim from any source without using quotation marks and the full reference is plagiarism. Plagiarism is a serious violation of academic integrity regardless of whether it is a homework exercise, an exam, a thesis, or a manuscript for publication.

University policies may be viewed on line. Important policies include:

Sexual Harassment (AD41)

Professional Ethics (AD47)

Parking Rules (BS04)

Intellectual Property (RA11)

<http://www.guru.psu.edu/policies/>

Graduate Student Policies are available on line

These include:

Grade mediation (G-10)

Resolution of problems (Appendix II)

Termination of program (Appendix III)

Termination of assistantship (Appendix IV)

Residency requirements (Appendix V)

<http://www.gradsch.psu.edu/policies/student.html>

II. THE AEROSPACE GRADUATE PROGRAM

Areas of Emphasis

The Department provides coursework and research projects in the following areas of emphasis: analytical/computational fluid dynamics, aeroacoustics, experimental fluid dynamics, flight science and vehicle dynamics, dynamics and control, rotorcraft engineering, structural dynamics/structures and materials, space propulsion, and turbomachinery. Graduate students may combine any number of these in a program leading to the M.Eng., M.S., or Ph.D. degrees.

The student's academic advisor typically works with the student in selecting courses and research areas. A temporary advisor is assigned to each student upon entry into the program. The student is encouraged to subsequently select a permanent advisor from among the faculty after becoming more acquainted with them and their research, preferably by the end of the first semester.

Course Offerings

AEROSPACE ENGINEERING UNDERGRADUATE COURSE DESCRIPTIONS

001S. *Aerospace Explorer* (1) First-Year Seminar explores aerodynamics, structural mechanics, flight mechanics, rotorcraft systems, high performance computers, air/space propulsion and space systems. Offered both semesters.

097S. *Hands-on Helicopters* (1) The Hands-On Helicopters First Year Seminar will introduce first year students to the fascinating world of vertical flight during the summer semester. Students will visit a helicopter hangar, see a radio-controlled helicopter demonstration, and participate in several activities to learn about the basic properties of helicopters. Each meeting period (8 period's total) will include a 75-minute instruction period followed by a 90-minute lab session.

199. *Foreign Studies* (1-12) Courses offered in foreign countries by individual or group instruction.

204H. *Flight Vehicle Design and Fabrication I* (2) Integrated project management, design, fabrication, testing, and flight evaluation of an advanced composite flight vehicle. Intended for Schreyer Scholars (freshmen and sophomores).

299. *Foreign Studies* (1-12) Courses offered in foreign countries by individual or group instruction.

301. *Aerospace Structures I* (3) Aerospace structural design concepts, flight safety. Stiffness, strength, stability of thin-walled structures under combined loads. Energy methods, finite element analysis. Prerequisite: EMch 213 or EMch 210. Prerequisite or concurrent: Aersp 313.

304. *Dynamics and Control of Aerospace Systems* (3) Vibrations of single, multiple, and infinite degree-of-freedom systems; operational methods applied to aerospace vehicles; design of controllers. Prerequisites: Aersp 313, EMch 212.

305W. *Aerospace Technology Lab* (3) Experiments in measurement systems, aerodynamics, aerospace structures, dynamics and control, and propulsion, technical report writing and presentations. Prerequisite or concurrent: Aersp 301, Aersp 311, Engl 202C.

306. *Aeronautics* (3) Lift and drag characteristics of aircraft; propulsion systems; airplane performance; introduction to stability and control. Prerequisites: Aersp 311, 313.

**308H. *Mechanics of Fluids* (3) Kinetics and dynamics of fluids; perfect fluid theory using complex variables; introduction to viscous flow theory; fundamentals of compressible flow. Prerequisites: EMch 212 or 212H; Math 251.

309. *Astronautics* (3) Introduction to space and space flight; laws of particle mechanics; orbits and trajectories; space vehicles and propulsion. Prerequisites: EMch 212, Math 250, CmpSc 201 or 202.

311. *Aerodynamics I* (3) Fluid statics and kinematics; fluid dynamics of inviscid and viscous flows; Navier-Stokes equations; introduction to boundary layers. Prerequisites: EMch 212, Math 250, CmpSc 201 or 202.

312. ***Aerodynamics II*** (3) Fluid mechanics of viscous and compressible flows, laminar boundary layers, turbulent flows, isentropic flows, shock waves, supersonic lift and drag. Prerequisites: Aersp 311, 313, ME 201.
313. ***Aerospace Analysis*** (3) Mathematical methods applied to aerospace engineering: Fourier series, ordinary and partial differential equations, complex variables, numerical methods. Prerequisites: Math 220, 230, 250, CmpSc 201 or 202.
399. ***Foreign Studies*** (1-12) Courses offered in foreign countries by individuals or group instruction.

The following 400-level courses may be taken by upperclassmen and graduate students:

- 401A. ***Spacecraft Design - Preliminary*** (3) Conceptual and preliminary design of a spacecraft, its constituent subsystems, and related systems, to satisfy a given set of specifications. Prerequisite: Aersp 309. Prerequisite or concurrent: Aersp 450.
- 401B. ***Spacecraft Design - Detailed*** (2) Detailed design of the constituent subsystems and related support systems for a spacecraft. Prerequisites: Aersp 401A, 301.
- 402A. ***Aircraft Design - Preliminary*** (3) Conceptual and preliminary design of an aircraft, its constituent subsystems, and related systems, to satisfy a given set of specifications. Prerequisite: Aersp 306. Prerequisite or concurrent: Aersp 413.
- 402B. ***Aircraft Design - Detailed*** (2) Detailed design of the constituent subsystems and related support systems for an aircraft. Prerequisites: Aersp 402A, 301.
- *404H. ***Flight Vehicle Design and Fabrication II*** (3) Integrated project management, design, fabrication, aerodynamic and structural testing, and flight evaluation of an advanced composite flight vehicle. Prerequisite: Aersp 204H.
- *407. ***Aerodynamics of V/STOL Aircraft*** (3) Rotary wing aircraft; VTOL and STOL performance; propeller-wing combinations; jet flap; high lift devices. Prerequisite: Aersp 312.
410. ***Aerospace Propulsion*** (3) Analysis and performance characteristics of reciprocating engine, turbo-jet, turbo-prop, turbo-fan, ram-jets, and chemical rockets. Aerothermodynamics of inlets, combustors, and turbomachinery. Prerequisite: Aersp 312.
- *412. ***Turbulent Flow*** (3) Homogeneous turbulence, spectral transfer of energy, viscous dissipation; turbulent shear flow: mixing-length theory, eddy viscosity, scaling laws, energy budget. Prerequisite: one course in fluid mechanics.
413. ***Stability and Control of Aircraft*** (3) Static and dynamic stability and control of aircraft; open and closed loop systems. Prerequisites: Aersp 304, 306.
- *420. ***Principles of Flight Testing*** (3) In-flight and analytical studies of airplane performance, stability, and control; reduction of data; instrumentation; flight test techniques. Prerequisite: Aersp 306.
- *423. ***Introduction to Numerical Methods in Fluid Dynamics*** (3) Finite difference methods applied to solving viscous/inviscid fluid dynamics problems, error control, and numerical stability. Prerequisites: Aersp 312 or ME 320; CmpSc 201 or 202; Math 250 or 251.
- *424. ***Advanced Computer Programming*** (3) Engineering and scientific programming topics: object oriented programming, parallel programming, and various modern languages (e.g. C++, Java, and Ada). Prerequisites: CmpSc 201 or 202 or equivalent, Math 220.
- *425. ***Theory of Flight*** (3) Advanced wing and airfoil theory, conformal mapping, slender body theory. Prerequisite: Aersp 306.

*430. **Space Propulsion and Power Systems** (3) Analysis and performance of chemical and nuclear rockets, electric propulsion systems. Introduction to solar, chemical, thermoelectric, and nuclear power sources. Prerequisite: Aersp 410 or ME 432.

*440. **Introduction To Software Engineering For Aerospace Engineers** (3) Software engineering for safety- and mission-critical systems, including requirements, management, processes, designs, programming, validation/verification, and other aspects of software development. Prerequisite: CmpSc 201 or CmpSc 202.

450. **Orbit and Attitude Control of Spacecraft** (3) Principles of mechanics and vector analysis applied to basic concepts of satellite motion and control, rocket ballistics, and gyroscopic instruments. Prerequisites: Aersp 304, 309.

*460. **Aerospace Control Systems** (3) Design and analysis of feedback control systems for aerospace applications; stability, root locus, time- and frequency-domain, state-space methods. Prerequisite: Aersp 304.

*470. **Advanced Aerospace Structures** (3) Design and analysis of aerospace structures. Plates and sandwich panels; composite materials; structural dynamics; aeroelasticity; damage tolerance. Prerequisite: Aersp 301. Prerequisite or concurrent: Aersp 304, EMch 315.

*473. (EMch 473) **Composites Processing** (3) An introduction to the principles of mechanics governing manufacturing, computer-aided design, and testing of composite materials and structures. Prerequisite: EMch 471.

*490. (EE 490, NucE 490) **Introduction to Plasmas** (3) Plasma oscillations; collisional phenomena; transport properties; orbit theory; typical electric discharge phenomena. Prerequisite: EE 330 or Phys 467.

*492. (ASTRO 492, EE 492) **Space Astronomy and Introduction to Space Science** (3) The physical nature of the objects in the solar system; the earth's atmosphere, ionosphere, radiation belts, magnetosphere, and orbital mechanics. Prerequisites: Phys 400 or EE 330.

*494. **Aerospace Undergraduate Thesis** (1-3 per semester, maximum of 6) Individual problem investigations reported in written thesis and seminar lectures. Cooperative research with faculty guidance on topics of current interest. Prerequisite: seventh-semester standing.

*496. **Independent Studies** (1-18)

*497. **Special Topics** (1-9)

*497B. **Experimental Methods and Projects** (3) Established experimental methods used in a variety of research areas in aerospace engineering. The lectures and practice laboratory sessions are accompanied by an engineering project that utilizes a more advanced measurement technique in experiments.

*497I. **Spacecraft Environment Interactions** (3) This course will examine various aspects of spacecraft aerodynamics and interactions with the space environment. The course will include some aspects of spacecraft design and the latest computational methods for calculating spacecraft aerodynamic forces and moments and thruster plume contamination.

*497K. **Aerospace Engineering Projects** (3) Team projects involving design, build, test of major components of aeronautical or astronautical vehicles (including software development or simulation). The course emphasizes methods for planning and monitoring the projects.

499. **Foreign Studies** (1-12) Courses offered in foreign countries by individual or group instruction.

*Technical Elective Courses. Some of these may not be offered every year.

**Service courses not applicable to Aerospace Engineering program.

500-LEVEL COURSES

Any senior with at least a 3.50 grade-point average may be admitted to 500-level courses with the consent of the instructor. This approval is only for coordination purposes. In fact, undergraduate students are encouraged to take one or two graduate courses in their undergraduate curriculum; this is particularly beneficial for students considering the pursuit of a graduate program following their BS degree. Seniors with a 3.00-3.49 average may be admitted to graduate courses with the consent of the instructor, the student's academic adviser, and the associate dean of the Office of Graduate Student Programs. Graduate courses can be used as technical electives.

504. *Aerodynamics of V/STOL Aircraft* (3) Jet wings, high lift devices, propellers and ducted propellers, circulation and boundary layer control, unsteady airfoil theory. Prerequisite: AERSP 407.

505. *Aero- and Hydroelasticity* (3) Interaction of elastic systems having several degrees of freedom with fluid flows in various configurations.

506. *Rotorcraft Dynamics* (3) Modeling and analysis techniques for dynamic response, vibration, aeroelastic stability, and aeromechanical stability of rotary wing-vehicles. Prerequisites: AERSP 504, EMCH 571.

507. *Theory and Design of Turbomachinery* (3) Theory and principles of machinery design: compressors, turbines, pumps, and rotating propulsors; opportunity to work out design examples.

508. *Foundations of Fluid Mechanics* (3) Mathematical review, fluid properties, kinematics, conservation laws, constitutive relations, similarity principles, the boundary layer, inviscid flow, vorticity dynamics, wave motion.

509. *Dynamics of Ideal Fluids* (3) Irrotational flow theory, two-dimensional and axisymmetric flows, airfoil theory, complex variables, unsteady phenomena; flow with vorticity, finite wing theory. Prerequisite: AERSP 508.

510. *Compressible Flow* (3) Classification and solution of compressible flow problems, high-speed gas dynamics, unsteady motion, transonic and hypersonic flows, atmospheric reentry.

511. *Aerodynamically Induced Noise* (3) Review of fluid mechanics. General theory of aerodynamic sound. Noise radiation from jets, boundary layers, rotors, and fans. Structural response.

512. *Viscous Flow* (3) Stress-deformation relations; Newtonian fluids, Navier-Stokes equations; exact, asymptotic laminar solutions; instability, transition; similitude and turbulent boundary layer.

514. *Stability of Laminar Flows* (3) The stability of laminar motions in various geometries as influenced by boundary conditions and body forces of various kinds.

518. *Dynamics and Control of Aerospace Vehicles* (3) Dynamical problems of aircraft and missiles including launch, trajectory, optimization, orbiting, reentry, stability and control, and automatic control. Prerequisite: AERSP 413 or 450.

524. (ME 524) *Turbulence and Applications to CFD: DNS and LES* (3) First of two courses: Scalings, decompositions, turbulence equations; scale representations, Direct and Large-Eddy Simulation' modeling; pseudo-spectral methods; 3 computer projects. Prerequisite: a graduate-level course in fluid mechanics.

525. (ME 525) *Turbulence and Applications to CFD: RANS* (3) Second in two courses: Scalings, decomposition, turbulence equations; Reynolds Averaged Navier Stokes (RANS) modeling; phenomenological models; 3 computer projects. Prerequisite: Aersp 524.

526. (ME 526) *Computational Methods for Shear Layers* (3) Study of numerical solution methods for steady and unsteady laminar or turbulent boundary-layer equations in two and three dimensions. Prerequisite: AERSP 423 or ME 523.

527. (ME 527) *Computational Methods in Transonic Flow* (3) Numerical solution of partial differential equations of mixed type, with emphasis on transonic flows and separating boundary layers. Prerequisite: AERSP 423 or ME 523.

528. (ME 528) **Computational Methods for Recirculating Flows** (3) Numerical solution techniques for laminar/turbulent flow with large recirculation zones. Both primitive variable and stream function-vorticity equations used. Prerequisites: AERSP 423, ME 523.
529. (ME 529) **Advanced Analysis and Computation of Turbomachinery Flows** (3) Review of numerical methods; three-dimensional inviscid flow computation; two- and three-dimensional viscous flow effects and computation; recent advances. Prerequisites: AERSP 423, AERSP 507 or ME 422.
530. **Aerothermochemistry of Advanced Propulsion Systems** (3) Physics and chemistry needed to analyze advanced rocket propulsion systems including reacting high temperature radiating gas and plasma flows. Prerequisites: AERSP 312 or ME 420.
535. (ME 535) **Physics of Gases** (3) An introduction to kinetic theory, statistical mechanics, quantum mechanics, atomic and molecular structure, chemical thermodynamics, and chemical kinetics.
540. (EE 571, NUC E 540) **Theory of Plasma Waves** (3) Solutions of the Boltzmann equation; waves in bounded and unbounded plasmas; radiation and scattering from plasmas. Prerequisite: AERSP (EE, NUC E) 471.
550. **Astrodynamics** (3) Applications of classical celestial mechanics to space flight planning. Determination and construction of orbital parameters by approximation methods. Perturbation techniques. Prerequisite: AERSP 450 or EMch 410 or Phys 419.
560. **Finite Element Method in Fluid Mechanics and Heat Transfer** (3) Introduction to finite element method, interpolations, numerical integration, iso-parametric elements, variational principles, method of variations, method of weighted residuals, potential flow solutions, transient heat conduction, parabolic diffusion problems, full potential equations solutions for transonic flows.
571. (ME 571, EMch 571) **Foundations of Structural Dynamics and Vibration** (3) Modeling approaches and analysis methods of structural dynamics and vibration. Prerequisites: Aersp 304, EMch 470, ME 450, or ME 470.
590. **Colloquium (Seminar)** (3) Presentations of ongoing research in aerospace engineering by faculty and senior doctoral students.
596. **Independent Studies** (1-18)
597. **Special Studies** (1-18)
- *597A. **Rotorcraft Aeromechanics** (3) This experimental course is divided approximately 50-50 between helicopter stability and control and helicopter acoustics. This course is computer intensive and requires you to write the following three programs: prediction of rotor performance in hover using vortex theory; prediction of rotor performance in hover and forward flight; and prediction of stability and motion.
- *597A. **Advanced Experimental Methods and Projects** (3) Established experimental methods used in a variety of research areas in aerospace engineering. The lectures and practice laboratory sessions are accompanied by an engineering project that utilizes a more advanced measurement technique in experiments.
- *597C. **Statistical Orbit Determination** (3) This course is an introduction to the mathematics and practices in statistical orbit determination. The major topics are: classical orbit determination techniques, probability and statistics, least squares solution, weighted least squares, statistical interpretation of the least squares problem, Cholesky decomposition, Gauss-Markoff theorem, sequential estimation algorithms, extended sequential estimation algorithms, square root filters, state noise compensation algorithm, state noise compensation algorithms, smoothing algorithms, minimum variance, maximum likelihood, Bayesian estimation. Other topics as time permits. Prerequisite: AERSP 450 or consent of the instructor.
- *597C. **Interplanetary Astrodynamics** Prerequisite: Aersp 450
- 597C. (897C) **Wind Turbine Systems** (3) Wind turbine technology and the critical elements of turbine system design. This course is primarily an online course with occasional group meetings. No prerequisite required.

*597E. **Linear and Nonlinear Estimation** (3) This course will cover estimation and data fusion for linear and nonlinear systems: (a) introduction to Gaussian random variable; (b) Gauss-Markov estimation and the Best Linear Unbiased Estimator; (c) minimum mean square error estimators; (d) Kalman filter; (e) Extended Kalman filter and the Sigma Point Kalman Filter; (f) effects of non-Gauss noise and non-Gaussian initial state estimates; (g) histogram and particle filters. Examples will be taken from aerospace and robotics applications, including (among others): fusion of GPS and inertial measurements; robot localization; target tracking; and simultaneous localization and mapping. (offered Spring semester in odd years)

*597F. **Behavior of Advanced Composite Structures** (3) Analysis techniques for composite beams, plates, and shells, energy and finite element formulations, elastic tailoring concepts, buckling of composite structures. Prerequisites: AERSP 302, EMch 471 or equivalent introductory course in composite materials.

*597F. **Smart Structures** (3) Over the last 10-15 years there has been tremendous interest in the use of smart materials as elements of “adaptive” structures. This class of materials includes, among others, piezoelectric materials, shape memory alloys, and electro- and magneto-rheological fluids. The course covers the fundamental behavior of these materials, their constitutive modeling, develops models for the introduction of smart materials as elements of adaptive structures (in particular for structural vibration reduction, damping augmentation, and shape control or morphing applications), addresses issues such as sizing and optimal placement of actuators and sensors in structures, and examines different control strategies and the resulting system behavior. Several smart materials application case studies are also presented.

*597G. **GPS Theory and Application** (3) This course will provide an understanding of the GPS architecture, signals, measurement, performance and estimation of position, velocity and time. It will cover augmentation such as differential GPS and carrier phase measurements. (Offered Spring semester in even years.)

*597I. **Spacecraft Environment Interactions** (3) This course will examine various aspects of spacecraft aerodynamics and interactions with the space environment. The course will include some aspects of spacecraft design and the latest computational methods for calculating spacecraft aerodynamic forces and moments and thruster plume contamination.

*597J. **Rotorcraft Stability and Control** (3) Development of a set of general equations of motion of a rotorcraft in maneuvering flight. The generalized trim problem. Linearized equations of motion and stability derivatives. Stability and control analysis of rotorcraft. Rotorcraft flight simulation. Handling qualities analysis and automatic flight control design for rotorcraft.

*597K. **Small Scale Turbomachinery** (3) Aero-thermo-mechanical design of small gas turbine systems for unmanned-aerial vehicle (UAV) systems.

599. **Foreign Studies** (1-2 per semester/maximum of 4) Courses offered in foreign countries by individual or group instruction.

600 Series – Graduate Level Research Courses

600 – **Thesis Research** – Credits used for M.Eng., M.S., and Ph.D.

601 – **PhD Dissertation Full-Time** – Ph.D. students will register for this 1-credit course the semester following the passing of the Oral Comprehensive Exam, and substantial completion of course requirements. (Students may also Audit one class when registered for 601.) (Graduate Staff Assistant will schedule the students eligible for this course.)

603. **Foreign Academic experience** (1 -12) Foreign study and/or research constituting progress toward the degree at a foreign university.

610 – **Thesis Research Off-Campus** – Used to complete thesis when student is no longer on campus or summer credits.

611 – **PhD Dissertation Part-Time** – Used to complete dissertation when student is no longer a full-time student.

* For **497** and **597** courses, suffix letters can change from year to year when determining what courses to take, be sure to check the course title.

AEROSPACE COURSE OFFERINGS SCHEDULE 2012-2013 ACADEMIC YEAR
Fall Semester 2013 **Spring Semester 2014**

AERSP Course	Cr.	Title	AERSP Course	Cr.	Title
001S	1	Aerospace Explorer	001S	1	Aerospace Explorer
097S	1	Hands-On Helicopters	097S	1	Hands-On Helicopters
204H	2	Flight Vehicle Design & Fabrication I	204H	2	Flight Vehicle Design & Fabrication I
301	3	Aerospace Structures	304	3	Dynamics and Control of Aerospace Systems
309	3	Astronautics	305W	3	Aerospace Technology Lab
311	3	Aerodynamics I	306	3	Aeronautics
313	3	Aerospace Analysis	308H	3	Mechanics of Fluids
401A	3	Spacecraft Design/Preliminary	312	3	Aerodynamics II
402A	3	Aircraft Design/Preliminary	401B	2	Spacecraft Design - Detailed
404H	3	Flight Vehicle Design & Fabrication II	402B	2	Aircraft Design - Detailed
405	3	Experimental Methods and Projects	404H	3	Flight Vehicle Design & Fabrication II
*407	3	Aerodynamics of V/STOL Aircraft	*423	3	Intro. to Numerical Methods in Fluid Dynamics
410	3	Aerospace Propulsion	*430	3	Space Propulsion and Power Systems
*412	3	Turbulent Flow	*440	3	Intro. to Software Engineering for Aerospace Engrs.
413	3	Stability and Control of Aircraft	*470	3	Advanced Aerospace Structures
*420	3	Principles of Flight Testing	*473	3	Composites Processing
*424	3	Advanced Computer Programming	*492	3	Space Astronomy and Intro. to Space Science
*425	3	Theory of Flight	494	1-3	Aerospace Undergraduate Thesis
450	3	Orbit and Attitude Control of Spacecraft	496	1-18	Aerospace Independent Studies
*460	3	Aerospace Control Systems	497A	3	Advanced Orbital Mechanics
*490	3	Introduction to Plasmas	497C	3	Wind Energy Engineering & Projects
494	1-3	Aerospace Undergraduate Thesis	497D	3	Special Topics in Aerodynamics
496	1-18	Aerospace Independent Studies	*497I	3	Spacecraft/Environment Interactions
504	3	Aerodynamics of V/STOL Aircraft	505	3	Aero and Hydroelasticity
508	3	Foundations of Fluid Mechanics	507	3	Theory and Design of Turbomachinery
514	3	Stability of Laminar Flows	509	3	Dynamics of Ideal Fluids
535	3	Physics of Gases	525	3	Turbulence and Applications to CFD:RANS
571	3	Foundations of Structural Dynamics and Vibration	550	3	Astrodynamics
590	1-3	Colloquium	590	1-3	Colloquium
596	1-9	Independent Studies	596	1-9	Independent Studies
597A	3	Advanced Experimental Methods and Projects	597B	3	Rotocraft Stability and Control
600	1-15	Thesis Research	597D	3	Special Topics in Aerodynamics
601	0	Ph.D. Dissertation Full-Time	597G	3	GPS Theory and Application
610	1-15	Thesis Research Off-Campus	597I	3	Spacecraft Environment Interactions
611	0	Ph.D. Dissertation Part-Time	600	1-15	Thesis Research
			601	0	Ph.D. Dissertation Full-Time
			602	1-3	Supervised Experience in College Teaching
			610	1-15	Thesis Research Off-Campus
			611	0	Ph.D. Dissertation Part-Time

Aersp 199, 299, 399, 499 (IL) (1-12 cr.) – Foreign Studies (effective Summer 2008) Technical Electives. Note: Not all of these are offered every year. Students must be admitted to the major to enroll in 300-level courses. Check with Aerospace Office late in the Spring Semester for Summer course offerings.

III ACADEMIC REQUIREMENTS & GUIDELINES

Graduate School Requirements

A detailed discussion of these requirements can be found in the Bulletin. All graduate students are urged to familiarize themselves with these requirements: (<http://www.bulletins.psu.edu/graduate/>)

- Registering for courses and completing your registration: <http://www.registrar.psu.edu/>
Please remember that if you are on an assistantship you will still need to file your bill on elion.
- General Requirements
- Grade-Point Average
- Time Limitation
- Off-Campus and Transfer Credits
- Advisors and Doctoral Committees
- English Competence
- Candidacy Examination
- Comprehensive Examination
- Final Oral Examination
- Thesis Acceptance
- Residence Requirement
- Continuous Registration

Departmental Requirements

The Department offers courses of study leading to three graduate degrees in Aerospace Engineering: the M.Eng., the M.S., and the Ph.D.

The M.Eng. is a non-thesis professional master's degree. It is usually a terminal degree for students who intend to pursue careers that do not emphasize research and development. However, it is sometimes obtained by highly qualified students who wish to accelerate progress towards a Ph.D. degree.

The M.S. is a thesis-based master's degree having a significant research component. It may be a terminal degree for students who intend to pursue research-related careers, or it may be a stepping-stone enroute to a Ph.D. degree.

The Ph.D. is a thesis-based doctor's degree. It is very strongly research-oriented and is a terminal degree for students who intend to pursue careers in research and development, research management, or university teaching.

Scholarship and Research Integrity (SARI) Program

The Scholarship and Research Integrity (SARI) program provides graduate students with opportunities to identify, examine, and discuss ethical issues relevant to their disciplines. All graduate students must participate in SARI training.

The SARI@PSU program is composed of two parts: an online training component (Part 1), and an interactive, discussion-based component (Part 2). The online training provides a common language and understanding of the history and principles of the responsible conduct of research. The discussion-based component provides an opportunity for in-depth exploration of important issues unique to each field of study.

Satisfying the Part 1 Requirement. The SARI@PSU website (<http://www.research.psu.edu/training/sari>) provides more information about the program, including FAQs and access to the online training on the Responsible Conduct of Research (RCR) that is used to satisfy the Part 1 requirement. This training is offered through the Collaborative Institutional Training Initiative (CITI, www.citiprogram.org).

Satisfying the Part 2 Requirement. Five (5) hours of activity is required. Students may attend up to two (2) workshops sponsored by the Office for Research Protections (ORP), such as Scholarship and Research Ethics brownbag lunches, for SARI credit. The ORP SARI Resource Portal (<http://www.research.psu.edu/orp/sari/>), provides information, teaching tools, and links to other resources.

The remainder of up to five (5) hours may be satisfied by attending SARI workshops or seminars organized by departments, colleges, or units such as the Rock Ethics Institute. For aerospace engineering students, at least one (1) of these hours must be satisfied by participating in a departmental activity, at least one of which is offered every semester.

Students can keep informed of ORP events by subscribing to the ORP listserv; email: L-ORP-Research-L-subscribe-request@lists.psu.edu.

Transmit the SARI check list electronically with all attachments to Nancy Nagle (ncn2@engr.psu.edu) only when fully completed and a minimum of three weeks before graduation. FAILURE TO COMPLETE THESE REQUIREMENTS IN A TIMELY MANNER MAY DELAY YOUR GRADUATION.

Supervision and Advising

Students are under the general supervision of their advisors. (See policy below concerning the assignment of an advisor.) All coursework for which the student registers for credit must be approved by the advisor on the Graduate Degree Program Plan Approval Form.

The form must be submitted to the advisor for approval and should be updated periodically. All completed forms should be given to the Graduate Program Staff Assistant.

The policy for assignment of advisors is as follows:

- Each new student is assigned an advisor prior to when he/she arrives.
- If a student is supported by research monies, then his/her advisor is **permanent** (i.e., advisors for Research Assistants and Research Aides are permanent).
- If a student is supported by non-research monies, i.e., departmental funds or any type of self-support such as private funds or fellowships, then his/her advisor initially is **temporary**. (i.e., advisors for Teaching Assistants, Teaching Aides, and students with government fellowships, etc. are temporary)
- Students with temporary advisors are encouraged to spend approximately two months meeting with Aerospace faculty before selecting a permanent advisor. Students should inform the Graduate Program Staff Assistant upon the selection of a permanent advisor.

Credit Loads and Academic Status ([http://www.psu.edu/bulletins/whitebook/\\$acadinfo.htm](http://www.psu.edu/bulletins/whitebook/$acadinfo.htm))

Students on assistantships should enroll for 12 credits, including thesis (AERSP 600). The Department normally commits to assistantship funding for graduate students for the duration of their degree studies providing they are making satisfactory progress toward their degrees. For M.S. or M.Eng degree candidates working as teaching assistants, the duration of this support is typically 3 semesters and then they become TAides, wages with no tuition support. Continued support for tuition, however, is only considered for students who have continuously enrolled in the recommended number of credits each semester as summarized in the table below.

Graduate Assistants--Graduate assistants must be enrolled at Penn State as graduate students. More specifically, since assistantships are provided as aids to completion of advanced degrees, assistants are expected to enroll for credit loads each semester that fall within the limits indicated in the table below. Maximum limits on permissible credit loads are indicated in order to assure that the student can give appropriate attention both to academic progress and assistantship responsibilities. These considerations give rise to the table of permissible credit loads below.

Level of Assistantship	Credits per Semester		Credits per 6-Week Summer Session	
	Minimum	Maximum	Minimum	Maximum
Quarter-time	9	14	5	7
Half-time	9	12	4	6
Three-quarter-time	6	8	3	5

To provide for some flexibility, moderate exceptions to the specified limits may be made in particular cases with the approval of the student's program head and the dean of the Graduate School via the Office of Graduate Enrollment Services. The Graduate School expects that an exception made in one semester will be compensated for by a suitably modified credit load in the subsequent semester, so that, on the average, normal progress is maintained at a rate falling within the limits above. Failure to do so may jeopardize the student's academic status. Maintenance of the established credit loads and responsibility for consequences of a graduate student's change of course load rest with the student and adviser. The course load is a factor in determining whether a graduate student is classified as a full-time or part-time student; has met residence requirements; and is eligible to hold a fellowship, traineeship, assistantship, or departmental or program appointment.

Graduate assistants whose credit loads equal or exceed the minima indicated in the table, and whose assistantship activities are directly related to their degree objectives, are considered by the Graduate School to be engaged in full-time academic work.

Full-Time Academic Status--Students holding fellowships, traineeships, or other awards based on academic excellence are required to carry 9 or more credits each semester. A graduate assistant whose semester or summer session credit load exceeds the minima in the above credit table and whose assistantship duties are directly related to his or her degree objectives is considered by the Graduate School to be engaged in full-time academic work for that semester. A post-comprehensive doctoral candidate who is registered for SUBJ 601 also is so considered.

Part-Time Academic Status--A student who in any semester or summer session is registered for study but who does not meet the criteria for full-time status is considered to be engaged in part-time academic work for that semester. This includes students registered for SUBJ 611.

Credit Loads for Internationals--The Department of Homeland Security requires that international students proceed in a timely fashion toward completion of their degrees, as established by the academic department and (usually) stated on their initial immigration document. Failure to maintain normal progress toward completion of the degree during this period will jeopardize the student's ability to continue academic study, adjust status, or seek future employment in the United States. Because of this, students should not be enrolled less than full-time during fall or spring semester without approval of International Student Services (ISS), 410 Boucke Building.

The U.S. Department of Homeland Security requires the ISS to report violations of status, including failure to maintain full-time enrollment. The following is intended to provide guidance for international graduate students and for ISS in determining full-time status:

--A graduate student is considered full-time if registered for a minimum of 9 credits, excluding courses taken for audit, or if a Ph.D. candidate who has successfully completed the comprehensive examination and is registered for SUBJ 601.

--On rare occasions, and under exceptional circumstances, international students in master's degree programs who have completed all required course work and, if applicable, research for their degree, may be granted an exception to the need to maintain full-time status as defined above, for a limited period (in no case to exceed two semesters), by special petition to ISS in advance of the semester in which the exception is needed. This request must be accompanied by a letter from the chair of the graduate program in which the student is enrolled verifying that all course and any research requirements have been completed, and indicating support for the request. ISS may consult with the Office of the Dean of the Graduate School in determining whether specific requests are appropriate and justified.

--Under all circumstances, international students must maintain registration for at least 1 credit.

Core Course Requirements

Basic Field Theory: (6 credits) - Complete one course in two out of the following three categories: Fluid Mechanics, System Dynamics or Solid Mechanics; for a total of 6 credits.

Fluid Mechanics:

_____ AERSP 508 – Foundations of Fluid Mechanics

System Dynamics:

_____ ACS 519 – Sound Structure Interaction
_____ AERSP 506 – Rotorcraft Dynamics
_____ AERSP 518 – Dynamics and Control of Aerospace Vehicles
_____ AERSP 550 - Astrodynamics
_____ AERSP 571 – Foundations of Structural Dynamics and Vibrations
_____ AERSP 597C – Interplanetary Astrodynamics
_____ AERSP 597J – Rotorcraftstab/Con
_____ EMch 520 – Advanced Dynamics
_____ PHYS 530 – Theoretical Mechanics

Solid Mechanics:

_____ AERSP 505 – Aero- and Hydroelasticity
_____ AERSP 597 – Behavior of Advanced Composite Structures
_____ AERSP 597F - Smart Structures
_____ EMch 500 – Advanced Mechanics of Materials
_____ EMch 507 – Theory of Elasticity and Applications
_____ EMch 540 – Introduction to Continuum Mechanics
_____ ME 560 – Solid Mechanics

Numerical/Computational Methods: (3 credits)

_____ ACS 597B – Computational Acoustics
_____ AERSP 423 – Introduction to Numerical Methods in Fluid Dynamics
_____ AERSP 526 – Computational Methods for Shear Layers
_____ AERSP 527 – Computational Methods in Transonic Flow
_____ AERSP 528 – Computational Methods for Recirculating Flows
_____ AERSP 529 – Advanced Analysis and Computation of Turbomachinery Flows
_____ AERSP 560 – Finite Element Method in Fluid Mechanics and Heat Transfer
_____ AERSP 596 – Individual Studies
_____ AERSP 597 – Introduction to Many-Body Problems and Algorithms
_____ AERSP 597G – Theory and Application of Global Navigation Satellite Systems
_____ ABE 513 – Applied Finite Element, Finite Difference, and Boundary Element Methods
_____ CE 541 – Structural Analysis
_____ CE 563 – Systems Optimization using Evolutionary Algorithms
_____ EMch 560 – Finite Element Analysis
_____ EMch 597B – Dynamics & Vibration of Non Linear Systems
_____ MATH 441 – Matrix Algebra
_____ MATH 523 – Numerical Analysis I
_____ MATH 550 – Numerical Linear Algebra
_____ MATH 551 – Numerical Solution of Ordinary Differential Equations
_____ MATH 552 – Numerical Solutions of Partial Differential Equations
_____ MATH 553 – Introduction to Approximation Theory
_____ MATH 555 – Numerical Optimization Techniques
_____ MATH 556 – Finite Element Methods
_____ ME 523 - Numerical Solutions Applied to Heat Transfer and Fluid Mechanics Problems
_____ ME561 – Structural Optimization Using Variational and Numerical Methods
_____ NucE 530 – Parallel/Vector Algorithms for Scientific Applications
_____ Stat 500 – Applied Statistics
_____ Stat 515 - (Chem 560) – Stochastic Processes

Applied Mathematics: (3 credits)

_____ EMch 524A – Mathematical Methods in Engineering
_____ EMch 524B – Mathematical Methods in Engineering
_____ EMch 550 – Variational and Energy Methods in Engineering
_____ EMch 597B – Dynamics Vibration of Non Linear Systems
_____ MATH 505 – Mathematical Fluid Mechanics
_____ MATH 507 – Dynamical Systems I
_____ MATH 508 – Dynamical Systems II
_____ MATH 509 – Linear Analysis and Applications I
_____ MATH 510 – Linear Analysis and Applications II
_____ MATH 511 – Ordinary Differential Equations I
_____ MATH 512 – Ordinary Differential Equations II
_____ MATH 513 – Partial Differential Equations I
_____ MATH 514 – Partial Differential Equations II
_____ MATH 580 – Introduction to Applied Mathematics I
_____ MATH 581 – Introduction to Applied Mathematics II
_____ PHYS 525 – Methods of Theoretical Physics I
_____ STAT 500 – Applied Statistics

(Other courses may be substituted with advance approval of advisor and the Director of Graduate Studies **before** you begin the course)

M.Eng. Degree

- A total of at least 30 credits are required for the M.Eng. Degree
 - A scholarly paper (2 credits of AERSP 596)
 - A graduate seminar (1 credit of AERSP 590)
 - Other course credits—minimum of 27
- Restrictions on course credits
 - Maximum of 6 credits at 400-level
 - Minimum of 21 credits of aerospace courses
 - At least 18 credits of these must be at 500-level
(Including the credits for the seminar and the scholarly paper)
(Exceptions can be made by advance petition and approval.)
- Core course requirements
(Other courses may be substituted with advance approval of advisor and the Director of Graduate Studies **BEFORE** you begin the course.)

Minimum grade point average for completion of all graduate degrees is 3.0

All courses used to satisfy degree requirements must be technical in nature, i.e. engineering, mathematics, or physical sciences.

Self-supported or fellowship students who register for at least 9 credits are considered to be engaged in full-time academic work for that semester. If such a student wishes to register for more than 15 credits, an exception to the normal maximum load must be granted through petition (with advisor's approval) to the Office of Graduate Enrollment Services.

Students with a half-time assistantship need to register for 12 credits, typically 9 credits of course work and 3 credits of research.

Credit loads for Internationals – The Immigration and Naturalization Services (INS) requires that international students proceed in a timely fashion toward completion of their degree, as established by the academic department and (usually) stated on their initial immigration document. Failure to maintain normal progress toward completion of the degree during this period will jeopardize the student's ability to continue academic study, adjust status or seek future employment in the United States. Because of this, students should not be enrolled less than full-time during Fall or Spring semesters without approval of the Office of International Students and Scholars (OISS) 410 Boucke Building. (Less-than-full time form needs to be completed by student's advisor and returned to ISS for review and approval prior to the beginning of the semester requested.)

The Department of Aerospace Engineering frequently supports M.S. and M.Eng. Students as Teaching Assistants (TA). Our practice is to provide such Teaching Assistant support for three (3) semesters, followed by one (1) semester of support as a Teaching Aide. The Teaching Aide is a wage payroll position with no tuition or health insurance coverage. A Teaching Aide position provides students with support equivalent to that of the Teaching Assistant stipend, with possible support for tuition. Thus, students are expected to substantially complete their course requirements in the first three semesters; this involves enrolling for approximately 10-12 credits per semester.

Students may want to apply for the Tuition Assistance Program in the Summer Session to maximize tuition monies. Only students that have been on an assistantship may apply.

A bound copy of the Scholarly Paper is required for the Department.

TIME LIMITATION: All requirements for a master's degree (including acceptance of a thesis, paper, or project report as may be specified), whether satisfied on the University Park campus or elsewhere, must be met within eight years of admission to degree status. Individual programs may set shorter time limits. Extensions may be granted by the Director of Graduate Enrollment Services in appropriate circumstances.

*Information obtained from Graduate Degree Program Bulletin accessed at: <http://www.bulletins.psu.edu/graduate/>

M.S. Degree

- A total of at least 30 credits are required for the M.S. Degree
 - Thesis credits - minimum of 6
 - Course credits - minimum of 24
- Satisfactory completion of a M.S. thesis is required for graduation.
- Restrictions on course credits
 - Maximum of 6 credits at 400-level
 - Minimum of 6 credits of 500-level aerospace courses
 - Minimum of 12 credits of aerospace courses
 - Core course requirements - see below
- Core course requirements (other courses may be substituted with advance approval of advisor and the Director of Graduate Studies **before** you begin the course)

Minimum grade point average for completion of all graduate degrees is 3.0

All courses used to satisfy degree requirements must be technical in nature, i.e. engineering, mathematics, or physical sciences.

Self-supported or fellowship students who register for at least 9 credits are considered to be engaged in full-time academic work for that semester. If such a student wishes to register for more than 15 credits, an exception to the normal maximum load must be granted through petition (with advisor's approval) to the Office of Graduate Enrollment Services.

Students with a half-time assistantship need to register for 12 credits, typically 9 credits of course work and 3 credits of research.

Credit loads for International students – The Immigration and Naturalization Services (INS) requires that international students proceed in a timely fashion toward completion of their degree, as established by the academic department and (usually) stated on their initial immigration document. Failure to maintain normal progress toward completion of the degree during this period will jeopardize the student's ability to continue academic study, adjust status or seek future employment in the United States. Because of this, students should not be enrolled less than full-time during Fall or Spring semesters without approval of the Office of International Students and Scholars (OISS) 410 Boucke Building. (Less-than-full time form needs to be completed by student's advisor and returned to ISS for review and approval prior to the beginning of the semester requested.)

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Students may want to apply for the Tuition Assistance Program in the Summer Session to maximize tuition monies. Only students that have been on assistantships may apply.

Student will need to present their thesis at a public forum. Please provide an abstract of your thesis and thesis title, along with the date, and time you would like to present at least two weeks prior to presenting to the Graduate Program Staff Assistant so that a room can be arranged and notice of the presentation can be prepared and distributed.

A M.S. thesis requires three signatures: your advisor, a reader, and the Department Head.

Provide two bound copies of thesis is required. (One copy for the advisor and one copy for the department).

TIME LIMITATION: All requirements for a master's degree (including acceptance of a thesis, paper, or project report as may be specified), whether satisfied on the University Park campus or elsewhere, must be met within eight years of admission to degree status. Individual programs may set shorter time limits. Extensions may be granted by the Director of Graduate Enrollment Services in appropriate circumstances.

*Information obtained from Graduate Degree Program Bulletin at: <http://www.bulletins.psu.edu/graduate/>

Direct Admission to Ph.D. Program

Admission to the Ph.D. program requires satisfactory completion of a master's program in engineering, physical science, or mathematics. Admission to the Ph.D. program prior to completion of a master's degree may be considered upon the student passing the Ph.D. candidacy exam. A student must have completed at least 18 course credits beyond the baccalaureate degree in order to take the Ph.D. candidacy exam, and is not granted official status as a doctoral candidate until the master's degree is complete and the candidacy exam has been passed.

Ph.D. Degree Requirements

Doctoral students must satisfy the Core Requirements. Graduate course requirements in addition to those specified in the Core Requirements are set by the candidate's doctoral committee on an individual basis. In general, there is no specified number of credits for the Ph.D. degree; however, students typically take at least 24 course credits beyond the M.S. degree. The doctoral dissertation will involve research activity normally exceeding one full year of full time graduate work equivalent to 30 credits; exact requirements are determined by a student's doctoral committee. The minimum GPA for completion of the Ph.D. degree is 3.0.

- Core course requirements (other courses may be substituted with advance approval of advisor and the Director of Graduate Studies **before** you begin the course)

Experimental Requirement: (Do one of the following)

- Perform dissertation research having an experimental component.
- Serve as TA for AERSP 305W.
- Take a course that emphasizes laboratory measurements, and error analysis, such as AERSP 420, AERSP 597A (Advanced Experimental Methods), ME 530, ME 536, ME 544, EMch 506, EMch 528, or ACS 505.
- Perform independent study (1 credit AERSP 596) by arrangement by your advisor. This could involve assisting another graduate student with experimental measurements, supervising an undergraduate laboratory project, or another activity.
- Other requirements
 - ENGR 588 (for TAs and TAides)
 - Dissertation

In addition to the aforementioned requirements, doctoral students must satisfy the following Graduate School requirements:

- Candidacy Exam
- Advisors and Doctoral Committee
- English Competency
- Comprehensive Examination
- Final Defense of Dissertation
- Residence Requirement
- Continuous Registration

These are discussed in the Bulletin. Implementation procedures within the Department, where appropriate, are discussed on the following pages. <http://www.bulletins.psu.edu/graduate/>

Candidacy Examination

In Aerospace Engineering, the Candidacy Examination is given each Fall and Spring Semester within the first two months of the semester. Each Ph.D. program enrollee is required to take the examination during his or her second semester following enrollment; however, those who have been out of an academic environment for a year or more immediately preceding their enrollment may petition for a one-semester delay in taking the examination. A memo from the student's advisor to the Director of Graduate Studies requesting this deferral must be submitted at least two weeks before the scheduled candidacy exam.

PH.D. CANDIDACY EXAM INFORMATION

	<u>Fall 2013</u>		<u>Spring 2014</u>
Date:	October 5, 2013	Date:	February 1, 2014
Location:	220 Hammond Building	Location:	TBD
Schedule:	9 am – 3 pm	Schedule:	9 am – 3 pm

PLEASE NOTE:

The following candidacy exam problems (without solutions) are now available for all interested students:

Fall 1990 thru Fall 2010

Students are provided with a copy of a Schaum's Outline on fundamentals of Engineering, and can use this book during the exam. (DO NOT ADD ANYTHING TO THE BOOK).

Copies of practice candidacy exams and Schaum's Outline are located on ANGEL for your viewing convenience, as well. Students are permitted to use a calculator that has no ability to communicate to the outside world.

DESCRIPTION OF CANDIDACY EXAM (POLICY G5)

Ph.D. CANDIDACY EXAMINATION (Revised format – July 1996)*

PURPOSE

The Ph.D. candidacy examination is intended to provide an additional measure (beyond what can be determined from the admissions documents) of a student's preparation for doctoral work. This is particularly useful for a student whose earlier degrees were obtained in non-aerospace engineering programs and/or from other institutions. To be successful in a Ph.D. program, students must understand a range of subjects beyond the particular topic of their dissertation research; hence, the candidacy exam should assess breadth of knowledge, posing questions from the primary fields that constitute our discipline: dynamics, fluids, mathematics, and structures. The exam does not require mastery of all four fields, but instead allows the student some choice in demonstrating a sufficient level of understanding in several areas.

FORMAT

Faculty will prepare three questions in each of the four subject areas, following the respective syllabus. Each problem is to be appropriate for a senior-level undergraduate or introductory-level graduate treatment of the subject. The exam is closed book, except for formulas provided with the examination questions. You may obtain this formula book to familiarize yourself with what is provided from the Graduate Staff Assistant prior to the exam.

A student taking the exam must attempt any eight of the twelve problems; the time limit for the exam is six hours. As a guideline, a passing grade is 75%, based upon the sum of all eight grades.

ADMINISTRATION

The Director of Graduate Studies will form four committees, giving each the responsibility to: 1) generate three problems, with solutions, and 2) carefully check the problems for clarity and appropriate level of difficulty.

Following the exam, two faculty will grade each problem on a scale of 1 to 10, and average their scores to give a single grade for that problem. If the two scores differ by more than 2 points, the Director will ask them to confer and attempt to resolve the difference; if that is not possible, a third member will be asked to grade the problem and that score will be averaged with the other two.

The departmental faculty will then meet to review the grades and determine the outcomes. A student who fails the exam on the first attempt is allowed to take the subsequent exam (typically offered near the beginning of each semester). In the event of a second failure, a student is then removed from the Ph.D. program. A student who fails the exam twice may petition the Graduate Academic Committee in writing for an oral candidacy examination. If the petition is granted, the Director of Graduate Studies will form a committee of three faculty to administer the oral exam and request that they make a recommendation of "pass" or "fail;" the Graduate Committee will then make the final decision.

*NOTE: The July 1996 revised format replaces Aerospace Engineering Policy No. G5

Ph.D. Candidacy Exam Fluids Syllabus

CONTROL VOLUME ANALYSIS

Continuity, momentum and energy equations, applications

DIFFERENTIAL ANALYSIS OF FLUID MOTION

Kinematics

Rotation, vorticity, circulation

Continuity equation

Navier-Stokes equations

INCOMPRESSIBLE INVISCID FLOW

Euler equations

Bernoulli equation

Velocity potential and stream function

Elementary flows

Forces and moments acting on a body

Thin airfoil theory

Lifting-line theory

Slender-body theory

DIMENSIONAL ANALYSIS AND SIMILITUDE

Application to problems in aerodynamics, hydrodynamics, rotating machinery, etc.

INCOMPRESSIBLE LAMINAR AND TURBULENT FLOWS

Exact solutions of the Navier-Stokes equations

Laminar and turbulent pipe flow

Blasius boundary layer solution

Integral methods for laminar and turbulent boundary layers

Similarity analysis of laminar and turbulent boundary layers

Laminar jets and wakes

Eddy viscosity and mixing length concepts

Reynolds averaged equations

COMPRESSIBLE FLOWS

Thermodynamics

One-dimensional compressible flow

Speed of sound and Mach number

Alternative forms of the one-dimensional energy equation

Stagnation, static and critical quantities

Normal and oblique shock relations, shock polar

Hugoniot equation

One-dimensional flow with heat addition

One-dimensional flow with friction

Supersonic flow over wedges

Prandtl-Meyer expansions

Prandtl-Glauert equation

Linearized theory for thin airfoils

Full potential equation

EXAMPLE REFERENCES:

1. White, F.W., *Fluid Mechanics*, 2nd edition, McGraw-Hill, 1989.
2. Anderson, J.D., *Modern Compressible Flows, with Historical Perspective*, 2nd ed., Wiley, 1994.
3. Anderson, J.D., *Fundamentals of Aerodynamics*, 2nd ed., McGraw-Hill, 1991.
4. Munson, B.R., Young, D.F., Okiishi, T.H., *Fundamentals of Fluid Dynamics*, 2nd ed., Wiley, 1994.
5. Wilcox, D.D., *Basic Fluid Mechanics*, 2nd ed., DCW Industries.

**Ph.D. Candidacy Exam
Structures Syllabus**

STRESS AND STRAIN

- Definitions
- Differential equations of stress equilibrium
- Stress transformation under coordinate change, principal stresses, and maximum shear stresses
- Linear strain-displacement relation; tensor vs. engineering strains; compatibility equations
- Strain transformation, principal strains, and maximum shear strains
- Strain measurement using strain gages

MATERIAL BEHAVIOR

- Linearly elastic constitutive relations; isotropic, orthotropic
- Yield and failure theories; Von Mises and Tresca criteria
- Fatigue

THEORY OF SIMPLE STRUCTURAL MEMBERS (RODS, BEAMS, SHAFTS)

- Kinematic assumptions (e.g., Bernoulli-Euler beam)
- Differential equations of equilibrium; displacement and force boundary conditions
- Principle of superposition; St. Venant's principle
- Extension (displacements, strains, stresses)
 - Stress concentration (plane stress)
 - Extensional rigidity
- Bending (displacements, strains, stresses)
 - Build-up ("composite") beams
 - Modulus-weighted centroid, neutral axis; flexural rigidity
- Torsion (displacements, strains, stresses)
 - Thin-walled open sections; thin-walled open sections; thin-walled multi-cell closed sections
 - Shear flow
 - Shear center, elastic axis; torsional rigidity
- Transverse shear (displacements, strains, stresses)
 - Thin-walled sections

ENERGY METHODS

- Work and potential; strain energy; kinetic energy
- Principle of virtual work; Principle of stationary total potential energy
- Ritz method
- Complementary potential energy; Castigliano's theorems; Unit Load method

FINITE ELEMENT METHOD

- Truss and beam elements; nodal degrees of freedom; displacement functions
- Strain energy; potential or virtual work of applied loads
- Element stiffness matrices, load vectors associated with distributed loads
- Element-to-global coordinate transformation
- Assembly of global stiffness matrix and load vector; enforcing boundary conditions
- Recovery of element forces, stresses, and strains; reaction forces

ELASTIC STABILITY

- Concept of stability
- Overall column buckling; effects of end conditions, length, flexural rigidity
- Effects of initial imperfections or load eccentricity
- Buckling of rectangular plates under in-plane loads

EXAMPLE REFERENCES:

1. Donaldson, B.K., *Analysis of Aircraft Structures, An Introduction*, McGraw-Hill, 1993.
2. Allen, D.H. and Haisler, W.E., *Introduction of Aerospace Structural Analysis*, John Wiley & Sons, 1985.
3. Cook, R.D. and Young, W.C., *Advanced Mechanics of Materials*, Macmillan, 1985.
4. Megson, T.H.G., *Aircraft Structures for Engineering Students*, John Wiley & Sons, 3rd ed.

**Ph.D. Candidacy Exam
Dynamics Syllabus**

KINEMATICS

Orthogonal coordinate systems and transformations
 Cartesian, cylindrical, spherical systems
Motion in inertial and accelerating reference frames
 Rectilinear/curvilinear velocities and accelerations; Coriolis acceleration

MOMENTUM AND IMPULSE

Momentum and impulse – linear and angular
Newton's laws and D'Alembert's principle

WORK AND ENERGY PRINCIPLES

Hamilton's principle
Lagrange's equations

PARTICLE MECHANICS

Particle dynamics in a uniform gravitational field
Elementary orbital mechanics

RIGID-BODY DYNAMICS

Inertia tensor
Euler's equations
Torque-free motion
Gyroscopic devices

VIBRATION AND STRUCTURAL DYNAMICS

Lump-parameter systems
 Single and multiple DOF discrete systems
 Algebraic eigenvalue problem; natural frequencies and mode shapes
 Forced response of damped systems
Distributed-parameter systems (structures)
 Wave equation for rods; equation of motion for transverse vibration of beams
 Eigenvalue boundary value problem; natural frequencies and mode shapes
 Kinetic energy
 Rayleigh-Ritz method
 Modal superposition for forced response of damped structure

EXAMPLE REFERENCES:

1. Greenwood, D.T., *Principles of Dynamics*, 2nd ed., Prentice-Hall, 1988.
2. Marion, J.B. and Thornton, S.T., *Classical Dynamics of Particles and Systems*, 4th ed., Saunders College Pub., 1995.
3. Thomson, W.T., *Vibration Theory and Applications*, 4th ed., Prentice-hall, 1993.

**Ph.D. Candidacy Exam
Mathematics Syllabus**

ORDINARY DIFFERENTIAL EQUATIONS

First- and second-order equations
Homogeneous and inhomogeneous equations
Systems of ordinary differential equations
Elementary Laplace transforms
Series solutions
Sturm-Liouville equation

PARTIAL DIFFERENTIAL EQUATIONS

Classification of equations
Separable solutions
Boundary and initial value problems
Green functions
Similarity solutions
Characteristics

VECTOR CALCULUS

Scalars and Vectors
Dot and cross products
Conformal mapping
Evaluation of line integrals
Method of residues
Evaluation of real integrals

FOURIER SERIES

FOURIER AND LAPLACE TRANSFORMS

Inverse Laplace transforms

LINEAR ALGEBRA

Matrix operations
Eigenvalues and eigenvectors
Gaussian elimination
LU factorization

NUMERICAL ANALYSIS

Interpolation and root finding
Numerical integration
Finite difference approximations
Solution of ordinary differential equations
Solution of partial differential equations

SPECIAL FUNCTIONS

Bessel and Hankel functions
Legendre and Chebyshev polynomials

EXAMPLE REFERENCES:

1. Kreyszig, E. Advanced Engineering Mathematics, 7th ed., John Wiley & Sons, 1993.
2. Arfken, G.B., Mathematical Methods for Physicists, 3rd ed., Academic Press, 1985.
3. Wylie, C.R., and Barrett, L.C., Advanced Engineering Mathematics, 6th ed., McGraw-Hill, 1995.

(Note: given some duplication of material in these references, students need not review them all, but they are also encouraged to consult sources in addition to those listed here.)

Advisors and Doctoral Committees

Following admittance to a degree program, the student should confer with the head of that major program concerning procedures and the appointment of an academic advisor. Consultation or arrangement of the details of the student's semester-by-semester schedule is the function of the academic advisor. This person may be a member of the doctoral committee or someone else designated by the head of the major program for this specific duty. The academic advisor may be different from the dissertation advisor.

Doctoral Committee – General guidance of a doctoral candidate is the responsibility of a doctoral committee consisting of four or more active members of the Graduate Faculty, which includes at least two faculty members in the major field. The dissertation advisor must be a member of the doctoral committee. The dissertation adviser usually serves as chair, but this is not required. If the candidate is also pursuing a dual-title field of study, a co-chair representing the dual-title field must be appointed. In most cases, the same individual (e.g., dissertation adviser) is a member of the Graduate Faculty in both the major and dual-title fields, and in such cases may serve as sole chair.

At least one regular member of the doctoral committee must represent a field outside the candidate's major field of study in order to provide a broader range of disciplinary perspectives and expertise. This committee member is referred to as the "Outside Field Member." In cases where the candidate is also pursuing a dual-title field of study, the dual-title representative to the committee may serve as the Outside Field Member.

Additionally, in order to avoid potential conflicts of interest, the primary appointment of at least one regular member of the doctoral committee must be in an administrative unit that is outside the unit in which the dissertation adviser's primary appointment is held (i.e., the adviser's administrative home; in the case of tenure-line faculty, this is the individual's tenure home). This committee member is referred to as the "Outside Unit Member." In the case of co-advisers, the Outside Unit Member must be from outside the administrative home(s) of both co-advisers. In some cases, an individual may have a primary appointment outside the administrative home of the student's dissertation adviser and also represent a field outside the student's major field of study; in such cases, the same individual may serve as both the Outside Field Member and the Outside Unit Member.

If the candidate has a minor, that field must be represented on the committee by a "Minor Field Member." (For additional information related to minors for D.Ed. students, see "Major Program and Minor Field" under "D.Ed.—Additional Specific Requirements" in this *Bulletin*.)

A person who is not a member of the Graduate Faculty (and may not be affiliated with Penn State) who is otherwise qualified and has particular expertise in the candidate's research area may be added as a "Special Member," upon recommendation by the head of the program and approval of the dean of the Graduate School (via the Office of Graduate Enrollment Services). A Special Member is expected to participate fully in the functions of the doctoral committee. If the Special Member is asked only to read and approve the doctoral dissertation, that person is designated a Special Signatory. Occasionally, Special Signatories may be drawn from within the Penn State faculty in particular situations.

Graduate Faculty officially appointed by the Graduate School to a doctoral committee who then leave Penn State may maintain that committee appointment for up to one year if the student's graduate program and the Graduate School dean, through the Office of Graduate Enrollment Services, approve the request for this exception. A retired or emeritus faculty member may serve as a doctoral committee chair if, and only if, he/she was officially appointed and began chairing the committee prior to retirement and has the continuing approval of the program head and the Graduate School dean, through the Office of Graduate Enrollment Services. Otherwise, the committee must be revised to either remove the faculty member from the committee or change the individual's appointment to a Special Member.

The membership of doctoral committees should be periodically reviewed by the head of the program to ensure that all members continue to qualify for service on the committee in their designated roles. For example, if type of appointments, employment at the University, etc., have changed since initial appointment to the committee, changes to the committee membership may be necessary. If changes are warranted, they should be made as soon as possible to prevent future problems that may delay academic progress for the student (e.g., ability to conduct the comprehensive or final examinations).

Chair – The chair or at least one co-chair must be an active member of the graduate faculty of the specific doctoral program in which the candidate is enrolled. A retired or emeritus faculty member may chair a doctoral committee if he/she began chairing the committee prior to retirement as has the continuing approval of the department head or program chair. The primary duties of the chair are: (1) to maintain the academic standards of the doctoral program and the Graduate School, (2) to ensure that the comprehensive and final examinations are conducted in a timely fashion, (3) to arrange and conduct all meetings, and (4) to ensure that requirements set forth by the committee are implemented in the final version of the dissertation.

Responsibilities of Doctoral Committee – The doctoral committee is responsible for approving the broad outline of the student's program and should review the program as soon as possible after the student's admission to candidacy. Moreover, continuing communication among the student, the committee chair, the research supervisor, and the members of the committee is strongly recommended, to preclude misunderstanding and to develop a collegial relation between the candidate and the committee.

The "Graduate Student Committee Policies and Procedures and Committee Appointment Signature Page," can be obtained from the Graduate Program Staff Assistant and, when completed, will need to be approved by the Director of Graduate Studies. This form is necessary to initiate paperwork for formal appointment of the members by the Graduate School.

English Competency

The Graduate School requires a formal assessment of reading, writing, and speaking abilities in English for all Ph.D. students.

The Department of Aerospace Engineering implements the Graduate School English Proficiency Policy by focusing on the attainment of English proficiency as an important component of the development of student research skills. The Department's plan requires demonstration of high-level competence in the use of the English language, including reading, writing, and speaking. Please inform the Graduate Program Staff Assistant, at least one week in advance, of the date, time and place of the exam.

Initial Assessment of English Proficiency

The goal of the initial stage of assessment is to identify those students having serious deficiencies in their command of the English language. Upon entering the Ph.D. program, students normally meet with numerous departmental faculty, including the Department Head, the Director of Graduate Studies, and several potential faculty advisors. Each of these people has ample opportunity to informally assess student competence in English. It is the responsibility of the student's academic advisor to identify serious deficiencies and to recommend an immediate course of action. Recommended courses include ESL 114G-118G. The earlier a student attains English competency, the more effectively he or she can concentrate on developing research capabilities. The advisor will continue monitoring progress in this regard until the student passes the written (technical) candidacy examination.

English Proficiency Exam

Upon passing the candidacy exam, a student's faculty advisor will consult with the Director of Graduate Studies and initiate the constitution of a Doctoral Committee. The committee should be convened as soon as practical (normally within a semester upon passing the candidacy exam) to establish general student research direction and specific coursework requirements. As a natural part of this process, the committee will formally assess the student's English proficiency; this includes native and non-native English speaking students. The goal at this stage is to identify students having significant deficiencies in their command of English. In addition to informal discussions, the assessment will consist of the following elements:

(1) **Reading.** In consultation with the faculty advisor and committee, the student will identify several publications pertinent to the contemplated research project. The student will then read and summarize the contents of these publications in both the written dissertation proposal and its oral presentation.

(2) **Writing.** The student will prepare a preliminary research proposal at least 5 pages in length, including a tentative plan for Ph.D. coursework, and distribute it to the committee members for advance review. Faculty will evaluate it on the basis of logical organization, clarity, correct English usage, and technical content. A short expository writing assignment may be required in addition, at the faculty's discretion.

(3) **Speaking.** The student will prepare and make a presentation at least 20 minutes in length to the committee on the subject of the dissertation proposal. The student will respond to questions following the presentation. The committee will evaluate the presentation on the basis of logical organization, clarity, correct English usage, and technical content.

Upon completion of the first meeting, the committee will report on the student's English competency in three areas: reading, writing, and speaking. If no significant deficiencies are noted, the committee will attest to satisfaction of the Graduate School requirement. (Please inform the Graduate Program Staff Assistant at least one week in advance of the exam of the date and time. (The student does not need to be registered for classes when this exam is taken.)

Enhancement of English Competency

If, in the opinion of the majority of the committee members, significant deficiencies exist in any of the areas, the student will be required to enroll in appropriate remedial courses (from the following list). (Reading: ESL 116G. Writing: ESL 116G, ENGL 202C, ENGL 198G, ENGL 418. Speaking: ESL 114G, ESL 115G. Presenting: ESL 100A, ESL 312.) Attainment of a grade of "B" or better will be taken to constitute satisfactory completion of the corresponding requirement.

Comprehensive Exam

When a Ph.D. candidate has substantially completed all course work, a comprehensive examination is given. This exam is intended to evaluate the candidate's mastery of the major (and if appropriate, minor) field(s). Before taking the "comps," a student must have satisfied the English competence requirement, must have a minimum GPA of 3.00, and must be registered. (If the exam will be taken during the summer, the student should apply for the Summer Tuition Assistance Program early in the preceding Spring semester.) The student's doctoral committee administers the exam.

In Aerospace Engineering, the doctoral committee may, at its discretion, require the candidate to complete one or more written problems in advance of the oral exam. During the oral part of the comprehensive exam, the candidate typically presents a proposal for Ph.D. dissertation research, including a literature review (if that was not covered as part of the English proficiency exam), objectives, approach, preliminary results, and a plan for completion. A nominal duration for the presentation is 30-40 minutes. Following that presentation, the committee may pose questions regarding written problems (if any), the proposed research topic, and the general preparation of the candidate to pursue Ph.D. research. A favorable vote of at least two-thirds of the members of the committee is required for passing. In case of failure, it is the responsibility of the doctoral committee to determine whether the candidate may take another examination. Once the comprehensive exam has been passed, the student may register for AERSP 601 (reduced tuition) in subsequent semesters.

Please inform the Graduate Program Staff Assistant, **at least two weeks in advance**, of the date, time and place of the exam. Materials need to be processed by Graduate Enrollment Services and returned in time for the exam.

After a PhD candidate has passed the comprehensive examination and met the two-semester full-time residence requirement, the student must register continuously for each fall and spring semester, until the dissertation is accepted and approved by the doctoral committee.

When a period of more than six years has elapsed between the passing of the comprehensive examination and the completion of the program, the student is required to pass a second comprehensive examination before the final oral examination will be scheduled.

Final Oral Examination ("Defense")

The final examination of the doctoral candidate is an oral examination administered and evaluated by the entire doctoral committee. It consists of an oral presentation of the dissertation by the candidate and a period of questions and responses. Questions will relate in large part to the dissertation, but may cover the candidate's entire program of study, because a major purpose of the examination is also to assess the general scholarly attainments of the candidate. The portion of the examination in which the dissertation is presented is open to the public.

Normally the final "defense" may not be scheduled until at least three months have elapsed after the comprehensive examination was passed; a more typical time is in excess of a year. A student must be registered in the semester during which the exam is taken. (If the exam will be taken during the summer, the student should apply for the Summer Tuition Assistance Program early in the preceding Spring semester.)

Both the dissertation adviser and the student are responsible for ensuring the completion of a draft of the dissertation *and for adequate consultation with members of the dissertation committee well in advance of the oral examination. Major revisions to the dissertation should be completed before this examination.* It is the responsibility of the doctoral candidate to provide a copy of the dissertation to each member of the doctoral committee at least two weeks before the date of the defense. The dissertation should be in its final draft at the time of the oral examination; both the content and style should be correct and polished. A favorable vote of at least two-thirds of the members of the committee is required for passing. If a candidate fails, it is the responsibility of the doctoral committee to determine whether another examination may be taken.

Please inform the Graduate Program Staff Assistant **at least two weeks in advance** so that a room may be scheduled for the day and time requested and the needed paperwork obtained from Graduate Enrollment Services.

Please see the Graduate School requirements for additional information at: <http://www.bulletins.psu.edu/graduate/>

Residence Requirement

There is no required minimum of credits or semesters of study, but over some twelve-month period during the interval between admission to the PhD program and completion of the PhD program the candidate must spend at least **two semesters** as a registered full-time student engaged in academic work at the University Park campus. Full-time University employees must be certified by the department as devoting at least 20 hrs./week to graduate studies and/or dissertation research to meet the degree requirements. (See Credit Loads and Academic Status in the Bulletin.)

Continuous Registration

It is expected that all graduate students will be properly registered at a credit level appropriate to their degree of activity. (See Registration.) After a PhD candidate has passed the comprehensive examination and met the two-semester full-time residence requirement, the student must register continuously for each fall and spring semester, (beginning with the first semester after both of the above requirements have been met) until the PhD dissertation is accepted and approved by the doctoral committee. (Note that students who are in residence during summers must also register for summer sessions.)

Minimum grade point average from completion of all graduate degrees is 3.00.

All courses used to satisfy degree requirements must be technical in nature, i.e. engineering, mathematics, or physical sciences.

Program requires satisfaction of core requirements in order to graduate.

Student may use a maximum of 6 credits of 400-level courses.

Self-supported or fellowship students who register for at least 9 credits are considered to be engaged in full-time academic work for that semester. If such a student wishes to register for more than 15 credits, an exception to the normal maximum load must be granted through petition (with advisor's approval) to the Office of Graduate Enrollment Services.

Students with half-time assistantships should register for 12 credits, typically 9 credits of classes and 3 credits of research.

Credit loads for International students - The Immigration and Naturalization Services (INS) requires that international students proceed in a timely fashion toward completion of their degree, as established by the academic department and (usually) stated on their initial immigration document. Failure to maintain normal progress toward completion of the degree during this period will jeopardize the student's ability to continue academic study, adjust status or seek future employment in the United States. Because of this, students should not be enrolled less than full-time during Fall or Spring semesters without approval of the University Office of Global Programs 410 Boucke Building. (The Less-Than-Full Time form needs to be completed by the student's advisor and returned to Global Programs office for review and approval prior to the beginning of the semester requested.)

Students may want to apply for the Tuition Assistance Program in the Summer Session to maximize tuition monies. Students must have been on an assistantship and have scheduled Comprehensive or Final Oral Exam.

Six Steps in the Ph.D. Program

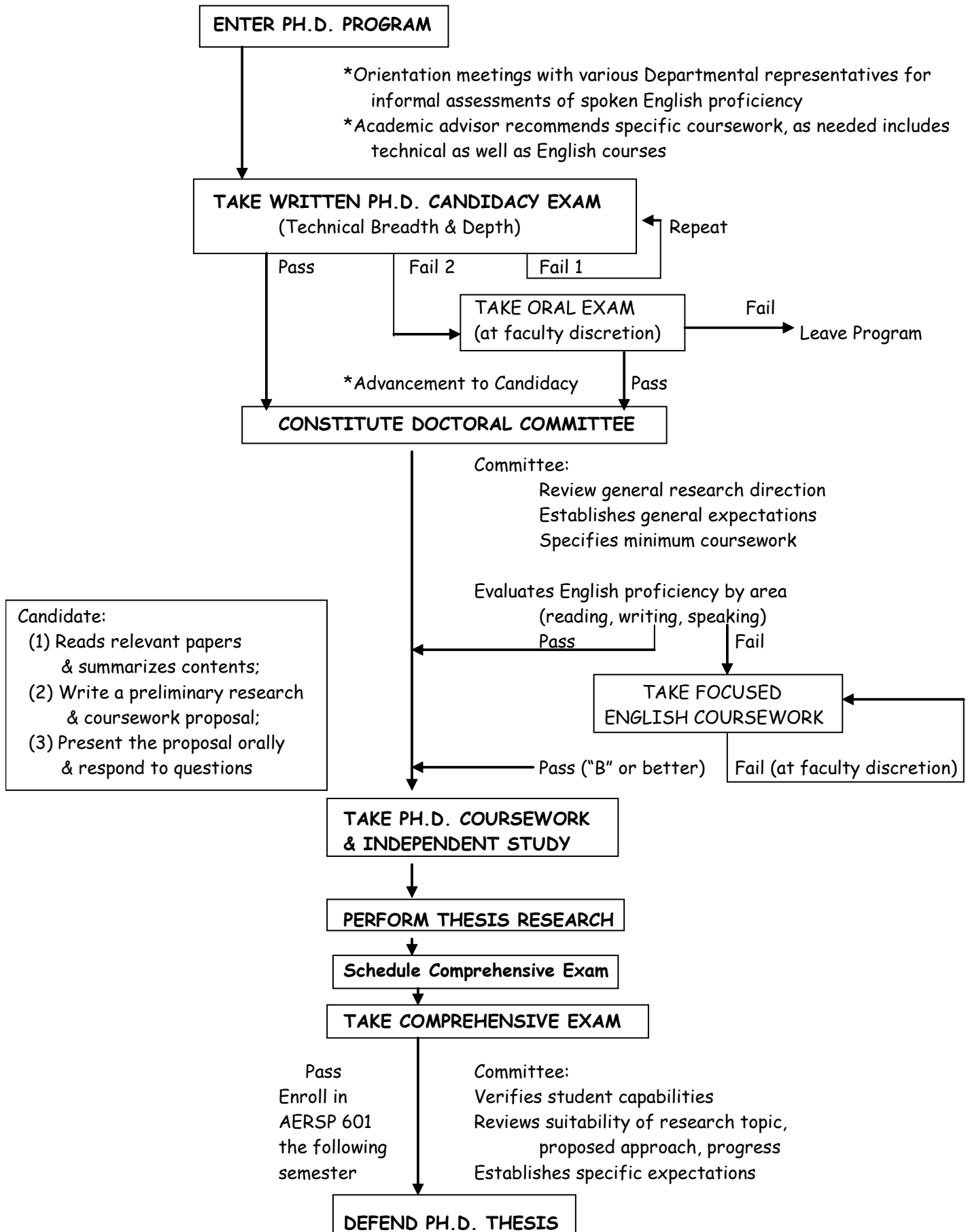
- 1) Pass Candidacy Exam
- 2) Form Doctoral Committee
- 3) English Proficiency Exam
- 4) Comprehensive Exam
- 5) Final Defense
- 6) Provide two bound copies of dissertation

Two bound copies of the dissertation is required for the Department (one copy for the advisor and one copy for the department).

TIME LIMITATION: All requirements for a doctoral degree (including acceptance of a dissertation, paper, or project report as may be specified), whether satisfied on the University Park campus or elsewhere, must be met within eight years from the date of successful completion of the candidacy examination. Individual programs may set shorter time limits. Extensions may be granted by the Director of Graduate Enrollment Services in appropriate circumstances.

*Information obtained from Graduate Degree Program Bulletin accessed at <http://www.bulletins.psu.edu/graduate/>

Ph.D. Flow Chart



Ph.D. Progress Sheet

1	<p>Candidacy Exam</p> <p>Need to take by: _____</p> <p>Deferred to: _____</p> <p>Passed: _____</p>	<p>In Aerospace Engineering the Candidacy Exam is given each Fall (October) and Spring (February) Semester. Each Ph.D. program enrollee is required to take the examination during his/her second semester following enrollment; however, those who have been out of an academic environment for a year or more immediately preceding their enrollment may petition for a one-semester delay in taking the examination. A memo from the student's advisor to the Director of Graduate Studies requesting this deferral must be submitted at least two weeks before the scheduled candidacy exam. The advisor needs to indicate why the deferral is being requested.</p> <p>Student must be registered for class in order to take the exam.</p> <p>Results will be given within two weeks of exam by the advisor.</p>
2	<p>Committee</p> <p>Chair: _____</p> <p>Major Members: _____ _____</p> <p>Outside Field Member: _____</p> <p>Minor: _____</p> <p>_____</p> <p>Date Formed: _____</p>	<p>Committee will consist of four or more active member of the Graduate Faculty, which includes at least two faculty members in the major field, and one Outside Field Member. The dissertation advisor must be a member of the doctoral committee and usually (but is not required to) serve as chair. If the candidate has a minor, that field must be represented on the committee. A person not affiliated with Penn State who has particular expertise in the candidate's research area may be added as a special member, upon recommendation by the head of the program and approval of the graduate dean. A special member is expected to participate fully in the functions of the doctoral committee. If the special member is asked only to read and approve the doctoral dissertation, that person is designated a <i>special signatory</i> of the dissertation.</p> <p>You will be provided with a Doctoral Committee Appointment Signature Form so that all information can be gathered and completed for signatures.</p> <p>Please be in contact with the Graduate Program Staff Assistant for more information.</p> <p>The Committee form must be completed and approved by Graduate Enrollment Services (GES) before any further steps can be taken towards the Ph.D. degree.</p>
3	<p>English Proficiency Exam</p> <p>Exam Date: _____</p> <p>Time: _____</p> <p>Place: _____</p>	<p>The committee should be convened as soon as practically (normally within a semester upon passing the candidacy Exam) to establish general student research direction and specific coursework requirements. As a natural part of this process, the committee will formally assess the student's English proficiency; this includes native and non-native English speaking students. The goal at this stage is to identify students having significant deficiencies in their command of English. In addition to informal discussions, the assessment will consist of the following elements: reading, writing and speaking.</p> <p>Once the committee has agreed upon a day and time for the exam the student needs to inform the Graduate Program Staff Assistant at least two weeks in advance so that the needed internal form can be prepared and a room be scheduled.</p>

4	<p>Comprehensive Exam</p> <p>Exam Date: _____</p> <p>Time: _____</p> <p>Place: _____</p>	<p>When a Ph.D. candidate has substantially completed all course work, a comprehensive examination is given. This exam is intended to evaluate the candidate's mastery of the major (and if appropriate, minor) field(s). Before taking the "comps" a student must have satisfied the English competency requirement, must have a minimum GPA of 3.0 and must be registered. (If the exam will be taken during the summer, the student should apply for the Summer Tuition Assistance Program early in the preceding Spring semester.) Student's doctoral committee administers the exam.</p> <p>Once the committee has agreed upon a day and time for the exam the student needs to inform the Graduate Program Staff Assistant <i>at least two weeks in advance</i> so that the needed paperwork can be prepared and sent to GES for approval and a room be scheduled.</p> <p>Students will be registered for AERSP 601 after completion of exam. (If coursework is substantially completed)</p> <p>Student must be continually registered until after final oral exam.</p>
5	<p>Final Oral Examination ("Defense")</p> <p>Exam Date: _____</p> <p>Time: _____</p> <p>Place: _____</p>	<p>The final examination of the doctoral candidate is an oral examination administered and evaluated by the entire doctoral committee. It consists of an oral presentation of the dissertation by the candidate and a period of questions and responses. Questions will relate in large part to the dissertation, but may cover the candidate's entire program of study, because a major purpose of the examination is also to assess the general scholarly attainments of the candidate. The portion of the examination in which the dissertation is presented is open to the public.</p> <p>A student must be registered in the semester during which the exam is taken. (If the exam will be taken during the summer, the student should apply for the Summer Tuition Assistance Program early in the preceding Spring semester.)</p> <p>Once the committee has agreed upon a day and time for the exam the student needs to inform the Graduate Program Staff Assistant <i>at least two weeks in advance</i> so that the needed paperwork can be prepared and sent to GES for approval and a room be scheduled.</p> <p>The student will also need to provide the dissertation title and abstract to the Graduate Program Staff Assistant <i>at least two weeks in advance</i> so that notice may be sent for the presentation of the dissertation.</p>
6	<p>Dissertation</p> <p>Sent to Bindery _____</p> <p>Gave copy to Department _____</p>	<p>Provide committee members with hard bound copy of dissertation. You will also need to provide a hard bound copy of your dissertation to the Graduate Program Staff Assistant.</p> <p>Further questions concerning dissertation deadlines and formatting can be located at http://www.gradsch.psu.edu/current/dissertation.html.</p>
7	<p>Exit Forms</p> <p>Completed: _____</p>	<p>Please see Graduate Staff Assistant for form.</p> <p>Please complete before you leave PSU.</p>

IV. RESEARCH AREAS & FACILITIES

Primary Research Areas

As illustrated in the figure on the following page, the Department provides coursework and research projects in the following areas of emphasis: analytical/computational fluid dynamics, aeroacoustics, experimental fluid dynamics, flight science and vehicle dynamics, dynamics and control, rotorcraft engineering, structural dynamics/structures and materials, space propulsion, and turbomachinery. Areas within these specializations include flow instabilities and turbulence, advanced airfoil design, rotorcraft dynamics, spacecraft dynamics, advanced composite structures, smart structures, advanced electric propulsion, and heat transfer.

Analytical / Computational Fluid Dynamics

Fast algorithms; grid generation; hypersonic flow; development of inverse design optimization methods; development of algorithms for massively parallel computers; turbulence; hydrodynamic stability; aeroacoustics; computations of large-scale turbulence structure in SCRAMJET combustors and in advanced nozzle designs; computations of various turbomachinery flowfields.

Aeroacoustics

Computational aeroacoustics (CAA) applied to jet noise, fan inlet and exhaust noise, acoustic liners, cavity noise, acoustic scattering, rotorcraft noise and wind turbine noise; semi-analytic predictions of jet noise; experimental studies of supersonic jet noise including nonlinear propagation effects and centrifugal fan noise.

Experimental Fluid Dynamics and Aeroacoustics

Measurements of the mean flow and turbulence structure in supersonic jets, PIV measurements in numerous flowfields including swirling jets, development of radar acoustic sounding system for the measurement of wake vortices.

Flight Science and Vehicle Dynamics

Analytical, computational and experimental programs in various areas including -aircraft design, performance, stability and control; airfoil design and analysis; low Reynolds number aerodynamics; wing-body aerodynamics, subsonic/hypersonic aerodynamics; aircraft operation; advanced concepts in V/STOL rotor control; propeller/stator interactions; rotorcraft aeromechanics.

Dynamics and Control

Spacecraft dynamics and control; astrodynamics; use of generalized perturbation methods for various problems of orbital motion.

Rotorcraft Engineering

Active control of rotor and drivetrain vibration and stability; modeling and characterization of elastomeric materials for dampers and bearings; dynamics of aeroelastically tailored helicopter and tiltrotor blades; computational aeroacoustics and aeroelasticity of rotors using parallel computers; dissimilar rotor systems for reduced vibration and noise; bearingless rotor optimization; rotorcraft health and usage monitoring.

Structural Dynamics / Structures and Materials

Analysis of flexible space structures; aeroelasticity problems in V/STOL aircraft; advanced composite materials; spacecraft dynamics and control; development of techniques for improved dynamic analysis of damped structures. Aerospace structures and advanced composite materials; experiments and analysis of filament wound composite structures; smart structures having embedded sensors and actuators.

Space Propulsion

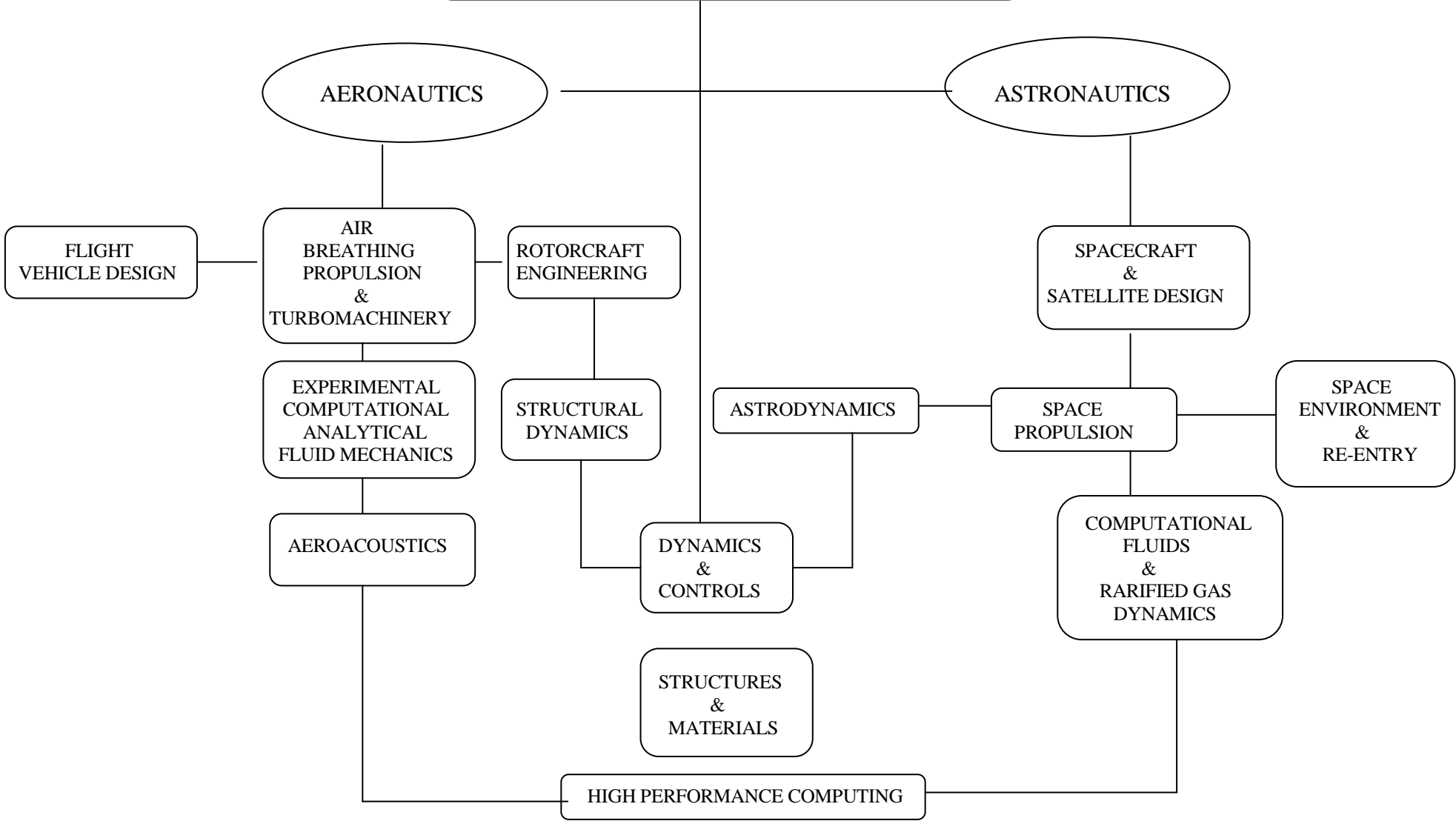
Rocket propulsion; instabilities in solid propellant combustion; microwave-heated advanced propulsion concepts; Monte-Carlo computations of advanced inlet and nozzle designs.

Turbomachinery

Aerothermodynamics of turbomachinery; convective heat transfer; short duration wind tunnel techniques and fast response instrumentation; turbulent flow; turbulence modeling; computations and measurements of three-dimensional turbulent flow in compressors and turbine rotors; aeroacoustics of turbomachinery and non-intrusive flow and thermal diagnostics in propulsion systems.

RESEARCH ACTIVITIES

AEROSPACE ENGINEERING DEPARTMENT



Computational and Experimental Facilities

Computer Facilities

Penn State has a wide array of state-of-the-art computational facilities available to aerospace engineering students, including parallel computing clusters, computer labs, and specialized equipment. These resources are distributed around campus, and are managed at a campus level by Information and Technology Services (ITS), in the College of Engineering by Electronics and Computer Services, and in the Department of Aerospace Engineering. Personal computers with both Windows and Linux operating systems are available in the student computer labs around campus.

The Aerospace Engineering Computer Lab, Room 131 Hammond Building, contains several Windows computers. Most of the computer labs are outfitted with laser printers as well. Accounts for using these computers are often established in various aerospace engineering classes. If you need accounts set up for the computers or the door card reader for the Aerospace Engineering Computer Lab, please see Mr. Mark Catalano, Department IT Manager. Mr. Catalano's office is located in Room 226 Hammond Building, or Kirk Heller, Systems Administrator, in 48 Hammond Building, or Jeff Friday, IT Specialist also located in 48 Hammond Building.

The Aerospace Engineering student computer lab has recently been upgraded with numerous computers and peripherals. A new Aerospace Computing Cluster Facility came on line during the fall of 2007. All of the major computer clusters have been relocated to Room 51 Hammond, which provide cooling and power for up to 16 racks of high density computer clusters. The computer clusters are funded through individual research projects – so graduate students have access to this facility based upon their need, with their research advisor's approval.

The PSU Information Technology Services (ITS) regularly holds classes and/or information sessions on operating systems and popular systems and application software available on the various computer platforms. Information regarding the ITS and its services may be obtained from any of the campus student computer labs or at <http://its.psu.edu>. Lab operators are often stationed in the computer labs to help with student computer needs. They are an excellent source of information if you have trouble with computer hardware/software, or just need information.

What follows is a summary list of popular software used by aerospace engineering students, grouped by type of application. This is not an all-inclusive list; rather, it is intended to give the student a feel for some of the software packages available for use. Detailed information on the software available can be obtained from the ITS, computer labs, or the lab operators. You could also use the world-wide web: <http://its.psu.edu>.

Computer hardware and software can be purchased at the Penn State Computer Store (Willard Building) or the Penn State Bookstore.

Programming

Programming software is used to create your own programs, often to solve engineering problems. Various programming languages, including FORTRAN, C, C++, MATLAB, and BASIC are available on most computer platforms. Ready-to-use software libraries, such as IMSL, LINPACK, and EISPACK, are available for student use through the network, providing specific code addressing typical engineering problems.

Word-processing

Word-processing software can be used to write, edit, and print reports, letters, documents, resumes, and theses. Microsoft Word is available on the personal computers.

Spreadsheets

Spreadsheet software is essentially used for dealing with numerical data. Data can be manipulated, analyzed, and plotted in a spreadsheet program. EXCEL is a spreadsheet software package available on the personal computers.

Computer Aided Design (CAD)

Computer aided design (CAD) software allows the user to build and manipulate a structure on a computer. Some advanced CAD packages, such as Pro Engineer on the PCs perform static and dynamic structural analysis and optimization. A simpler, more straightforward CAD package is AutoCAD2005, Solidworks Education edition, available on the personal computers in 131 Hammond Building.

Presentations

Presentation software can be used to create, edit, and print slide shows, handouts, and speeches. PowerPoint presentation software is available on the personal computers.

Math Software

Several math software packages are available to solve simple and complex mathematical problems. MathCAD is a symbolic math software processor. Matlab is available on the personal computers.

Software List on PCs in 131 Hammond

WINDOWS XP
AUTOCAD 2005
MS OFFICE 2003

- Word
- PowerPoint
- Access
- Excel

MATLAB 7.0
VISUAL Studio 2003.net
Norton Antivirus Corporate Editor
Satellite Tool Kit 7.1.1
PRO ENGINEER Wildfire
EXCEED 7.0
Fluent Gambit Tgrid
SolidWorks Education Edition 2005 SP3.1
Fieldview Fortran (Intel/g 95)

Internet Access

- Netscape 7.1
- Internet Explorer 6.0
- Firefox 1.5

Experimental Facilities

Numerous wind tunnels

Low-turbulence subsonic wind-tunnel with six-component strain gauge balance (3.25 x 5 foot test section); low-turbulence boundary layer tunnel (2 x 3 feet test section); anechoic open jet wind tunnel (28" x 72" test section); supersonic free shear layer facility (2 x 5 inch test section); convective heat transfer tunnel with real-time color image processing; compressed air flow facility (300-psi reservoir); several probe calibration jets, limited access to supersonic wind tunnel (6 x 6 inch test section).

Water channels/Water Tunnel

Laminar flow water channel (1.5 x 2.5 foot test section); limited access to the Garfield Thomas Water Tunnel of the Applied Research Laboratory.

Aeroacoustic facilities

A semi anechoic chamber and adjoining reverberation room. A large anechoic chamber with forward flight simulation. A gas mixture and heated jet facility to simulate jet engine exhausts for aeroacoustic studies.

Structures research laboratory

A high temperature bi-axial tension/torsion testing facility; an ultrasonic inspection system; hydraulic testing machine; structural dynamics lab; scanning laser vibrometer.

Composites materials laboratory

Autoclave (3 foot diameter x 7 foot length); a computer-controlled filament winding machine; a pultrusion machine; a braiding machine for composite materials manufacturing

Space propulsion facilities

High vacuum tank facility for low-density flow; unsteady propellant combustion facility; variable power microwave generator and propulsion facility; spectrometer and a CW Nd laser for space propulsion research

Several large turbomachinery facilities

Axial flow turbine; linear turbine cascade facility; 6' diameter rotor-rig.

Other experimental facilities include

Several laser Doppler anemometers including a subminiature semiconductor model; two partial image velocimeter systems; an ATC/510G flight simulator; a thermal analysis system; an acoustic emission system; reflection polariscope used in material fabrication and characterization

Duties for Department's Lab and Computer Coordinators**LABORATORY DIRECTOR**

The Laboratory Director assists the Aerospace faculty, staff, and students as needed in all technical aspects of instructional, academic and research-related laboratory activities. This position is presently filled by Mr. Richard Auhl, located in 226 Hammond Building. His areas of responsibilities include but are not limited to the following:

- Assist the Department Head with the implementation of department management strategies, staff software training, information systems development and strategic planning.
- Assist the faculty with undergraduate laboratory course instruction. (AERSP 305W)
- Coordinate the laboratory facility and department space allocation.
- Provide engineering and fabrication advice or assistance to faculty and students involved in project activity.
- Supervise the part-time laboratory assistants involved in general department maintenance.
- Serve as the primary contact person for the Dean's Office with regard to department space and facilities management.
- Coordinate and supervise all Machine Shop activities.
- Serve as the laboratory safety officer.

IT MANAGER

The IT Manager assists the Aerospace faculty, staff, and students as needed in technical aspects of computer and general electronic systems. This position is currently filled by Mr. Mark Catalano, located in 226 Hammond Building. His primary responsibilities are listed below in order of their importance to the Department:

- Maintain and support all computer and network related equipment in the Department.
- Responsible for upgrading the hardware and software of all computers in Department.
- Provide purchasing support to Department on computer/electronic related equipment.
- Diagnose electronics problems as they arise and repair or replace equipment.
- Responsible for the installation of new electronic equipment in the Department.
- Responsible for maintaining the card reader system in computer lab.
- Provide classroom support for A/V equipment when student aid is not available.
- Supervise part-time students working in the electronic shop.

Please feel free to contact Mr. Auhl or Mr. Catalano if you have any questions concerning Department laboratory facilities.

Description of Faculty Research Interests

ROTORCRAFT ACOUSTICS, COMPUTATIONAL AEROACOUSTICS AND HIGH PERFORMANCE COMPUTING

Kenneth S. Brentner, Ph.D., University of Cambridge, U.K.
Professor

ksbrentner@psu.edu

Research interests focus on rotorcraft and aircraft aeroacoustics, computational aeroacoustics, fluid mechanics, computational fluid dynamics, and high performance computing. Specific areas of research include rotor source noise prediction, prediction and characterization of rotorcraft noise in maneuvering flight, prediction of landing gear noise and other types of airframe noise. Recent research activities include the development of the rotorcraft noise prediction code PSU-WOPWOP which is able to predict noise from a rotorcraft with multiple rotors in both steady and maneuvering flight; prediction of noise generation and propagation from wind turbines; acoustic scattering for aircraft noise, including ducted rotors; and the development of a component based landing gear noise prediction system.

AEROTHERMODYNAMICS OF TURBOMACHINERY AND HEAT TRANSFER

Cengiz Camci, Ph.D., Von Karman Institute for Fluid Dynamics, Belgium
Professor

c-camci@psu.edu

Research interests focus on studies in fluid mechanics and heat transfer in turbomachinery systems. Specific areas of research include aerodynamic loss generation mechanisms, secondary flows, endwall contouring, turbulent boundary layers, film cooling of high pressure turbine blades, turbine airfoil design, wall heat flux measurements in turbines, non-intrusive measurement techniques (Laser Doppler anemometry LDA and particle image velocimetry PIV) applied to rotating machinery and digital image processing of liquid crystal covered surfaces for basic heat transfer studies. Recent research activities include the investigation of radar antenna aerodynamics, turbine tip leakage reduction, tip cooling, turbine intra-stage coolant ejection, heat transfer studies using an image processing based liquid crystal technique, elliptical pin-fins, oscillating fins for internal cooling passages, tip heat transfer in a linear cascade, trailing edge coolant injection and the implementation of a stereoscopic PIV in the rotor of an axial flow turbine. A new facility for the aero-mechanical testing of helicopter main rotor blades including icing is under development. Large scale computation of three dimensional unsteady and turbulent flow systems including rotational effects is currently being performed using a 25 processor computer cluster.

STRUCTURAL ACOUSTICS AND VIBRATION

Stephen Conlon, Ph.D., Pennsylvania State University
Research Associate and Assistant Professor

scc135@psu.edu

Research interests include; acoustic signatures/noise and vibration control of underwater systems, development of novel experimental procedures for radiated power assessments of underwater structures, space and ground vehicle system/structure health monitoring, and the structural design/control of large based antennas.

FLIGHT MECHANICS AND CONTROL

Joseph F. Horn, Ph.D., Georgia Institute of Technology
Associate Professor

joehorn@psu.edu

General research interests are in the areas of flight dynamics, automatic flight control systems, guidance and navigation, handling qualities, and flight simulation and modeling. Current research activities have focused on control system design and flight simulation for rotorcraft and rotorcraft UAV applications. Specific research topics include envelope protection systems, damage mitigating control, nonlinear adaptive control, integration of flight controls and health and usage monitoring systems, control design for compound helicopters, simulation and control of helicopter shipboard operations, autonomous control of UAV's, and coupled flight dynamics and acoustics simulation of rotorcraft.

COMPUTATIONAL FLUID DYNAMICS AND MULTIPHASE FLOWS

Robert F. Kunz, Ph.D., Pennsylvania State University
Senior Scientist and Head of the Computational Mechanics Division,
PSU Applied Research Laboratory, and Professor of Aerospace Engineering

rfk102@psu.edu

Research interests and activities are in the areas of computational fluid dynamics, multiphase flows, turbomachinery, hydropropulsion, reactor thermal-hydraulics and turbulence modeling.

AERONAUTICS AND ASTRONAUTICS

Jack W. Langelaan, Ph.D., Stanford University, California
Associate Professor

jwl16@psu.edu

Research interests include sensor fusion, estimation, trajectory planning and control of autonomous systems. Work involves algorithm development, simulation and hardware experiments.

STRUCTURAL DYNAMICS AND ACTIVE STRUCTURES

George A. Lesieutre, Ph.D., University of California, Los Angeles
Department Head and Interim Director of Center for Acoustics and Vibration

g-lesieutre@psu.edu

General research interests are motivated by aerospace vehicle applications, and include materials and controls for precision structures, vehicle dynamics and control, and systems engineering. Present activities address concepts for morphing aircraft structures, the dynamic behavior of elastomeric components in rotorcraft applications, piezoelectric actuators for structural control, energy harvesting using piezoelectric materials, and the nonlinear dynamics of particle dampers. Other research addresses the dynamic analysis of damped structures, structural composite materials with improved intrinsic damping, semi-active vibration control using tunable transducers and shunted piezoelectrics, shape determination for gossamer space structures, structural condition monitoring, and bio-inspired control. Experiments are an important part of much work, and improved measurement methods are also of concern.

MODELING OF CHEMICALLY REACTING FLOWS

Deborah A. Levin, Ph.D., Caltech
Professor

dal16@psu.edu

Dr. Levin's general area of research is the modeling of chemically reacting, transitional flows which are relevant to a number of important aerospace applications. When we consider the flow Knudsen number, the ratio of a characteristic dimension in the flow to the mean free path, many of the computational tools used to model space flows can also be used to model micro-propulsion systems. The challenges in simulating space-plume and hard body flows involves the development of physical models that provide sufficient fidelity to model thermo-chemical nonequilibrium effects in a computationally feasible manner. The computational flow techniques include direct simulation Monte Carlo and Navier-Stokes methods. Since space flows involve energetic collisions, radiation from chemically formed species may be observed by ground and space optical sensors. Optical radiation modeling of the emissions from these flows is therefore also an important part of the research being performed in the group. Research performed in the group is conducted using three new Beowulf clusters with an emphasis on parallel computing.

INTELLIGENT SYSTEMS, ROBOTICS, COMPUTATIONAL SCIENCE, AND SOFTWARE

Lyle N. Long, D.Sc., Aerospace Engineering, George Washington University
Distinguished Professor of Aerospace Engineering and Mathematics, Director of Computational Science Graduate Minor, in charge of Undergraduate Minor in IST for Aerospace (ISASP)

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Research interests are in a broad range of computing and information technology in both computational physics (e.g. CFD and Monte Carlo) and intelligent systems (e.g. neural networks and cognitive architectures) for ground and air-based mobile robots. Dr. Long teaches courses in advanced computer programming, software engineering, and computational methods. He also holds joint appointments in Acoustics, Bioengineering, Computer Science and Engineering, Neuroscience and Mathematics. For information on IST minor please visit: <http://www.personal.psu.edu/lnl/ist/>.

AERODYNAMICS, AIRCRAFT DESIGN AND STABILITY AND CONTROL

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Research interests are in the areas of aerodynamics, aircraft design, and stability and control. Current activities deal with the design and analysis of airfoils, low Reynolds number aerodynamics, wing planform optimization, uninhabited air vehicles, wind turbines, and experimental aerodynamics.

EXPERIMENTAL FLUID DYNAMICS AND AEROACOUSTICS

Dennis K. McLaughlin, Ph.D., Massachusetts Institute of Technology
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Research interests include experiments on a variety of fluid dynamic and aeroacoustic problems. Experiments are being conducted in the anechoic chamber with forward flight capability on a number of aeronautical applications. Most prominent are the experiments on high speed (transonic and supersonic) jets of various geometries. In these flows helium/air mixtures are used to simulate the high temperature exhausts of the jets. In addition, wind tunnel experiments and flight tests are being conducted as part of the development project for vertical takeoff aircraft using ducted lift fans.

ASTRODYNAMICS, SPACECRAFT DYNAMICS AND CONTROL

Robert G. Melton, Ph.D., University of Virginia
Professor and Director of Undergraduate Studies

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Astrodynamics, spacecraft dynamics and control; trajectory optimization, perturbation analysis of low-thrust orbital motion, orbit determination, dynamics and control of multi-body spacecraft.

ROCKET PROPULSION

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Research interests centers on rocket propulsion. Both experimental and analytical work is being conducted on the oscillatory burning of solid and liquid rocket propellants and how it affects rocket motor instabilities. Work is also being conducted on advanced propulsion concepts, in particular the heating of propellant gases to high temperatures by the absorption of microwave radiation. Experimental characterization using optical diagnostics of nozzle flows expanding into a vacuum is being undertaken.

TURBULENCE, AEROACOUSTICS AND HYDRODYNAMIC STABILITY

Philip J. Morris, Ph.D., University of Southampton
Associate Director of Institute for High Performance Computing Applications
Boeing/A.D. Professor of Aerospace Engineering

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Dr. Morris' research centers on the modeling and prediction of unsteady incompressible and compressible flows. The work is primarily analytical and computational. Current research projects include: the prediction of noise from high-speed jet flows; the prediction of airframe noise; the simulation of blast loading of complex structures; the prediction of contaminant dispersion in urban environments; wind turbine noise prediction; the simulation of aeroelastic phenomena; prediction of the nonlinear propagation of identification using near and far field arrays. Each of these analytical or computational studies is linked closely with experimental studies at Penn State, NASA Langley and Glenn Research Centers, The Boeing Company, GE Aviation and GE Energy, Sandia Laboratories, and the National Renewable Energy Laboratory.

AIRCRAFT ICING, ACTIVE STRUCTURES

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Research interests focus on aircraft and wind turbine icing, as well as experimental test and evaluation of active rotor blades. Specific areas of on-going research related to aircraft icing are engine ice crystal melting and accretion, experimental ice shape acquisition for model validation and aerodynamic performance degradation quantification, optimization and testing of low-power ice protection systems, and experimental evaluation of ice protective coatings. Research related to active structures includes design and centrifugal testing of active rotor systems instrumented with trailing edge flaps, micro trailing edge effectors, centrifugal power generation prototypes, and mechanical de-icing systems.

COMPUTATIONAL FLUID DYNAMICS (CFD)

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Research interest includes basic and applied Research in Computational Fluid Dynamics (CFD). Development of Hybrid RANS/Vortex methodologies for wind turbines and helicopters. Prediction of unsteady aerodynamic loads on wind turbine blades, effects of surface contaminations on blade performance. Designs and optimization of wind turbines and blades.

COMPOSITE STRUCTURES, ROTORCRAFT DYNAMICS, AND AEROELASTICITY

Edward C. Smith, Ph.D., University of Maryland
Co-Director of the Penn State Rotorcraft Center of Excellence
Professor

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Research interests include analytical modeling and experimentation focused on innovative applications of advanced composite structures to aerospace vehicles. Recent research has concentrated on the development of improved methods for the analysis of composite box-beams and rotor blade spars, and the aeroelastic and aeromechanical tailoring of helicopters with composite rotor blades. Research interests related to helicopter and tilt-rotor dynamics also include blade and airframe vibration reduction, gust response suppression, rotor and rotor-body stability augmentation, modeling of bearingless rotors, and helicopter flight simulation. Material damping of advanced composites and elastomers is also of particular interest.

ASTRODYNAMICS, SPACECRAFT DYNAMICS AND CONTROL

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Professor

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Research interests include astrodynamics, high accuracy orbit determination, space debris research, spacecraft trajectory optimization, spacecraft dynamics and control, interplanetary trajectory analysis, and space systems engineering.

RESEARCH CENTERS AND PROGRAMS IN ENGINEERING

Penn State Vertical Lift Research Center of Excellence

The Penn State Vertical Lift Research Center of Excellence (VLRCOE) is one of only three university research centers in the country focused on technical problems specific to rotary-wing and vertical flight aircraft. Funded by the US Army, US Navy and NASA, the Penn State Vertical Lift Research Center involves facilities, faculty and students from the Departments of Aerospace Engineering, Mechanical Engineering, and Engineering Science and Mechanics. Research thrust areas include rotor and vehicle dynamics, composite and smart structures, flight simulation and controls, cabin noise, rotor noise, rotor and airframe aerodynamics, drivetrain technologies, unmanned air vehicles, and condition-based maintenance. In addition to core Army and Navy support, many VLRCOE research projects are supported directly by the rotorcraft industry (e.g. Bell, Boeing, Sikorsky, Kaman, Lord Corp, Timken Corp, Goodrich, etc.), as well as NASA and other federal agencies. Over forty full-time graduate students are centrally located with our laboratories in brand new office space in Engineering Unit C. Our VLRCOE faculty and students are also actively involved in a wide range of educational programs, educating students from pre-school to graduate school and beyond. Vertical Lift Fellowships are available to provide additional financial support for outstanding graduate students. Undergraduate research assistantship positions are also available for highly qualified undergraduate engineering students.

Website: <http://www.engr.psu.edu/rcoe>

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Center for Acoustics and Vibration

Research in acoustics and vibration is one of Penn State's enduring strengths. The steady growth of research in acoustics and vibration in recent years establishes the Penn State program as the largest and most respected of its kind at a major research university. The Center for Acoustics and Vibration, housed in the Penn State College of Engineering, ensures the continued excellence of acoustics and vibration research in the 1990's.

The CAV has three missions:

- to strengthen basic and applied research in related engineering areas;
- to foster graduate education in acoustics and vibration engineering; and
- to provide a base for technology transfer to industry.

The center consists of faculty, graduate students and staff in nine laboratories throughout the College of Engineering and ARL. These laboratories perform both disciplinary and cross-disciplinary research in areas related to acoustics and vibration. Areas of research activity include:

Active control, adaptive structures, flow-induced noise, machinery prognostics and condition monitoring, propagation and radiation, rotorcraft acoustics and dynamics and structural vibration and acoustics.

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Propulsion Engineering Research Center at Penn State

With the support and guidance of the National Aeronautics and Space Administration, Penn State has established a Center for Space Propulsion Engineering Research. This is the result of a long history of a commitment to excellence in space-related engineering research and education. Its mission is to enhance and broaden the capabilities of America's engineering community to meet the needs of the expanding space program.

The Center is focusing on five major areas of research: Chemical Propulsion, Electric/Nuclear Propulsion, Advanced Propulsion Concepts, Diagnostics, and Materials.

The Center is housed primarily in the Departments of Aerospace Engineering, Mechanical Engineering and Engineering Science and Mechanics in the College of Engineering, with additional programs in other Engineering departments as well as in the Colleges of Science and Earth and Mineral Science.

Financial support for graduate work is available through either NASA Traineeships or Research Assistantships. NASA trainees receive stipends plus tuition and fees. Stipends for assistantships are competitive. Students involved in Center activities have an opportunity for direct interaction with NASA installations.

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APPENDIX A

DEPARTMENT OF AEROSPACE ENGINEERING

Development of a “Six-S” Laboratory Work Environment

Prepared for the Aerospace Faculty, Graduate
Students, and Undergraduate Students

INTRODUCTION

In recent years, with the growing enrollment and increased student project activity, Penn State Aerospace Engineering has experienced difficulty maintaining the organization and cleanliness of many areas of the Department allocated space. As a solution to this it has been suggested by the 2005 Industrial Professional Advisory Committee (IPAC) that we begin to adopt what is known in industry as a “Five-S” philosophy within our Department laboratories. We have decided to add an additional S to emphasize our need for SAFETY in the labs.

“Five-S” is one of the “lean manufacturing” tools developed by the Japanese in the 80’s and currently utilized by companies worldwide to organize their workspace and instill the discipline required to maintain a high degree of organization. Based mostly on common sense, the principles underlying Five-S are actually very simple; however, until the Five-S nomenclature became popular, many businesses ignored these basic concepts. Although we encourage the development of this philosophy in all of our laboratory areas, our near term goal is to work with students to specifically establish this philosophy in our shop and instructional laboratories.

The original Five-S’s are derived from the first letter of five Japanese words, and were chosen as a means of remembering the important elements of this philosophy. In the west, we have adopted several corresponding translations that maintain the Five-S framework.

<u>Japanese:</u>	<u>English Translation:</u>
Seiri	to <u>Sort</u>
Seiton	to <u>Set in Order</u> / or Straighten / or Systematically arrange
Seiso	to <u>Shine</u>
Seiketsu	to <u>Standardize</u> / or Simplify
Shitsuke	to <u>Sustain</u> / or exercise Self-discipline

SORT

The first step of this process is to decide what things are necessary to have in each specific work area. Everything must be sorted on the rubric of what will be used in the next month or two. In a personal office space it might be more productive to follow a 24 or 48 hour rule. Items should be “staged” in a central holding area in one of three possible categories (*keep, store, or discard*). Less frequently used items should be moved to storage or discarded. If multiple quantities of items exist, it should be determined how many of each is really needed. Most people will have to fight the temptation to keep things because they “may be useful someday”. During this sorting process, broken equipment and tools should be repaired or disposed of. The amount of work surfaces needed to perform your tasks should also be considered. The final goal of this step is to ensure that only those items that are needed to do the job remain in the most accessible locations.

SET IN ORDER

The second step of the process is to decide how to lay out the new workspace and where the important items should be located to promote the highest efficiency and effective retrieval. The overriding principle of this step is based on the familiar adage “a place for everything and everything in its place.” Often, floors are painted to outline work areas, shadow boards are installed to hold tools, and modular shelving or mobile cabinets are used for trash cans and cleaning supplies. Commonly used tools are made readily available, signs are used to inform people of designated locations for items, and shelves and books are labeled. In general, the more visually based the organization; the easier it will be to find and replace things. Critical elements of equipment and machinery, such as the piping and valves, should be clearly identified.

SHINE

The third step of the process is to thoroughly clean all of the work areas, and then continue to perform a daily follow-up cleaning. Workers are encouraged to keep things clean and polished after each use by taking pride in a clean and clutter-free work area. In a very real sense, each person should take ownership of the equipment and workspace they are working in. During the cleaning process it is particularly easy to inspect the machines, tools, equipment and supplies in an effort to identify potential problems. Each work area should develop a checklist of daily cleaning activities in an effort to make cleaning a high priority. Maintaining a laboratory’s appearance will not only increase efficiency, but also ease the pressure of preparing for VIP visits and encourage new project funding from research sponsors.

STANDARDIZE

The fourth step is perhaps the least obvious of the process. It involves defining an acceptable work ethic and standardization of work practices within a given area. Each worker should be involved in the development of these standards. In the words of Henry Ford, "every well thought-out process is simple" and each person should be looking for the best way to do things. Once this is determined, these methods should be documented to help future workers perform the same tasks efficiently. It is helpful to schedule a periodic review of your laboratory practices with other researchers to help identify areas to improve. It is important to have a work structure that will support the new practices listed in the first three steps, and help turn them into standard work habits. As more experience is gained in a work area, the standards should be updated and modified to keep them as simple as possible. Old work habits will need to be avoided if this philosophy is going to succeed. Each person must help to set a standard of cleanliness and organization in the labs and remind others of safe work habits.

SUSTAIN

The final step in the process is to repeatedly persevere with the four basic procedures listed above. It takes the continued commitment and dedication of everyone in the labs to maintain a philosophy like this.

SAFETY

Within this Department we want to be sure to emphasize the need to do everything with safety in mind. A Sixth "S" is therefore added to our rubric to remind us of this important emphasis.

YOUR COMMITMENT IS CRITICAL

- a.) As a student in Aerospace Engineering, we ask for your commitment to the Six-S philosophy and your help in establishing the standards of this new work environment within our Department.
- b.) We also ask for your commitment to inspire pride and adherence to the standards established in each work area.
- c.) Finally we ask for your commitment to educate other students about maintaining standards and helping us create a culture that implements these ideas in our everyday life at Penn State.

This is clearly an ongoing improvement process that will lead to less waste and an improved work environment for all of us. The Department will support this effort by initiating periodic reviews of each work area, implementing a formal system for monitoring the results, and applying a portion of this activity toward student project and research related grades.

Please inform the Laboratory Director, Rick Auhl, of any equipment or supplies that are needed to support this organizational effort within your area of research.

WHAT DO WE HAVE TO GAIN?

- 1) Improved laboratory safety and quality of workmanship.
- 2) Improved student, faculty, and staff morale.
- 3) Improved work efficiency and reduced time wasted searching for tools and equipment.
- 4) Increased pride in our Department's resources and facilities.
- 5) An Improved Department image regarding our capability and research effectiveness.
- 6) Increased available workspace and decreased storage costs.
- 7) Simplified laboratory work environments and standardization of work practices.
- 8) Reduced equipment damage and machine down time.
- 9) Establishment of good student work habits in preparation for industry employment.

DEPARTMENT OF AEROSPACE ENGINEERING

SAFETY MANUAL

Prepared by the Aerospace Safety Committee

Approved by the Aerospace Engineering Faculty

I, _____, have read the Aerospace Engineering Department Manual on Safety and agree to follow all safety procedures, as described in the guide, when using laboratories and equipment located in the Aerospace Engineering Department. I recognize it is solely my responsibility not to endanger myself and/or other students, staff, or faculty through unsafe practices.

Signature

Date

Return this form to the main office of Aerospace Engineering

SAFETY MANUAL

Aerospace Engineering Department

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I. INTRODUCTION

The objective of any safety program is to provide a safe working environment in which the hazards to all personnel are minimized. In order to accomplish this goal, safety must be the concern of all members of the institution. Suitable procedures must be devised and followed where potential hazards exist. Common sense must be relied upon to avoid accidents, and expedience is never an excuse for unsafe activities. This information booklet describes the safety regulations and procedures for the Aerospace Engineering Department. These procedures should be followed to ensure a safe environment for all our students, faculty and staff. Safety in our teaching and research laboratories are a direct concern of all the faculty, staff and graduate assistants involved.

II. SAFETY REGULATIONS

Posted in Room 233 and on our Departmental bulletin boards are the University instructions regarding accidents. These instructions include the appropriate telephone numbers and procedures to follow in case of an accident. In addition, it is important to note that: all accidents must be reported to the department office as soon as possible. In the case of an injury, please provide a complete description of the accident and the nature of the injury.

Employees are expected to work in a safe manner, using common sense to avoid accidents. Urgency of completing a test or the use of expedient procedures or equipment is no excuse for taking chances in the laboratory with unsafe conditions. However, even in situations where conscientious attention to safety is the rule, accidents can occur. When an accident does occur it is vital to follow established procedures which will insure the safety of all personnel involved. Once these procedures have been followed, proper reporting of the accident to departmental personnel should follow.

1. An individual is not permitted to work alone at a potentially hazardous task. For example, graduate students or staff are not allowed to operate power tools or similarly dangerous equipment at night unless a companion is in the immediate area.
2. Safety glasses and face shields are available in our machine shop area. Wear them when operating power tools, when around glass that might shatter, when using compressed gases, when working on pressure line connections, etc.
3. When operating electrical equipment avoid chances of grounding one part of your body while using your hands near “hot” lines. “One hand in the pocket” is a good rule. Make sure that your hands are completely dry when handling electrical tools. Don’t experiment with circuits you don’t understand; call a specialist.
4. Accumulation of fumes from volatiles such as gasoline is a great hazard. Use proper ventilation and fume hoods when possible.
5. Handling of compressed gas cylinders should be done with respect afforded to any potentially explosive material.
6. Storage of chemicals is not allowed in refrigerators unless the refrigerator is specially marked suitable for chemicals.
7. Do not block the inlet section of high mass flow rate rotating machinery. These areas should be well guarded with safety cages etc. in order to avoid foreign material suction.
8. Always use earphones when operating noisy test rigs such as axial flow fans, pumps, etc.

These items by no means cover all the problem areas: they do serve as examples. Experimental set-ups of a potentially dangerous nature (explosion, high voltage, high speed rotating machinery, experiments with propellants, etc.) are not to be operated until inspected and approved by our safety committee. It is the responsibility of the PRINCIPAL INVESTIGATOR to contact the safety committee when inspection is required. The committee recommendations will be reviewed by the Department head prior to approving continued operation of any equipment that offers a potential hazard to personnel.

III. SAFETY IN THE LABORATORY

A. Undergraduate in the Laboratory

With Departmental laboratories operating at full student capacity, the introduction of new laboratory projects and exercises result in increased chances of accidents. It is the direct responsibility of EACH FACULTY ADVISOR concerned with laboratory work to:

1. Take every safety precaution in designing and directing laboratory work.
2. Regularly observe students in action and to watch for unsafe practices and unsafe equipment. Encourage reporting of potential hazards.

SOME EXAMPLES OF HAZARDS ARE:

High voltages.

Eye hazards such as chemicals, compressed air or steam leaks, chipped and hammering
(SAFETY GLASSES ARE REQUIRED).

Rotating and moving machine parts, such as unguarded coupling or shaft ends that could snap clothing.

Smoking with volatile, combustible solids, liquids or gases nearby.

Compressed gas cylinders.

Laser radiation.

Loose clothing, long hair, wearing jewelry around rotating equipment.

Involving with electrical and welding if you are wearing soft contact lenses without a protective glass.

Using portable cassette players etc. with long/loose earphone cables when you are around rotating machine parts.

Graduate Students in the Laboratory

The Aerospace Engineering Department has a large and growing research program which involves a wide variety of sophisticated equipment and apparatus. Some of these research activities may involve potentially hazardous situations and thus require specific procedures for safe operation. Examples of such research areas include those involving high temperature and pressure conditions, concentrated energy sources, high power lasers, rotating machinery with high mass flow rate, high voltages, and liquid/solid propellants.

It is the direct responsibility of EACH FACULTY ADVISOR and GRADUATE STUDENT that safe procedures are observed in the laboratories.

THIS RESPONSIBILITY INCLUDES:

1. Taking appropriate safety precautions in the design and operation of each experiment.
2. Assuring that students and staff engaged in operating equipment are familiar with its operation and potential hazards.
3. Providing appropriate safety equipment in the laboratory. (safety glasses, earphones, respirators, etc.)
4. Where appropriate, start-up, shut-down and also EMERGENCY SHUT-DOWN procedures should be developed and posted.
5. Assuring that students are familiar with university and departmental safety and accident procedures.
6. Assuring that students and researchers are well informed about the locations of safety/emergency/ first aid material.

IV. SPECIFIC LABORATORY SAFETY PROCEDURES

A. SHOP SAFETY AND PROPER USE OF MACHINES

Power tools can cause injury if precautions are not taken. The tools in the shop work area are there for your use. It is expected that students will follow safe shop practices when using them.

Some basic procedures to follow to prevent abuse of the machines and possibly your person are:

1. Safety goggles must be worn when operating any power tools. Also, when hammering or using a punch, chips can fly off these tools. Goggles are available in the machine shop area.
2. When operating any power tool, jewelry, such as rings, bracelets, earrings, loose clothes (i.e. ties) etc., should be removed.
3. Individuals who have long hair should use a hairnet or other suitable means to prevent hair from being caught while operating any power tools.
4. Drill press – material being drilled should be secured to the table using a drill vise or other suitable clamping arrangement. Wear goggles, as drill bits can shatter. Be especially careful when drilling sheet metal or any thin materials. Drill bits frequently grab the material when the bit “breaks through”. This will instantly spin the workpiece, you then have something similar to an electric blender with the blades exposed; not good for the hand that is trying to hold the piece. Be extremely careful.
5. Bandsaw – the bandsaw is equipped for cutting 1/8” or thicker metal, wood or plastic. Avoid cutting sheetmetal, it tends to grab the teeth on the blade, removing them in short order. Never push a work piece with your hand or fingers in the same plane as the blade. Should your hand slip, you may find yourself cutting your hand or fingers. Always adjust the blade guide so it is just above your workpiece. This keeps the blade in alignment and vertical. The blade may come off its rollers if this isn’t done.
6. Grinder – always wear goggles. Never stand directly in front of the wheel, your piece can be grabbed or thrown by the wheel, often quite violently. Also, never grind wood, aluminum or softer metals, or plastic on a grinder. Particles of these materials become clogged in the wheel, ruining its effectiveness. Clogging can unbalance the wheel which can cause it to break and explode. Do not grind on the side of the wheel. This can shatter the wheel.
7. GENERAL – be courteous and professional. Horseplay doesn’t belong around power tools, someone could fall into the machine, the distraction could cause another to have an accident etc. Also, clean up after yourself when you are done, the debris left behind could lead to an accident.

B. LASER SAFETY

Lasers are utilized in a variety of research programs within the department and when operating in a proper manner they do not pose a significant safety hazard. However, if operated improperly they can pose significant electrical hazards as well as obvious hazards to eyesight. The following guidelines should be followed when operating any laser system:

1. Do not attempt to use any laser unless you are familiar with its operation and potential hazards and classifications (ANSI-2-136 Standard).
2. Where appropriate, use laser safety goggles designed for wavelength and power output of that laser.
3. Do not override the safety interlocks intended to prevent operation of the laser. For example, most laser systems prevent operation with the cover off the power supply or laser cavity (plasma tube).
4. When optical elements such as lens, prism, etc., are used with the laser, be careful about specularly reflected beams which result at each surface. These should be blocked to protect personnel in the lab from potential hazards. A neutral density filter on the laser beam should be utilized during the alignment of the optical component in addition to a safety goggle designed for that laser.
5. Never look directly into the laser beam.
6. Never allow the beams to cross windows or any other opening existing in the laboratory. The beams may be dangerous for others outside the lab.
7. It is a good idea to remove jewelry from fingers.
8. Make sure that your hands are completely dry before you switch a power supply on. This is especially important when operating a water-cooled laser power supply.

C. COMPRESSED GAS CYLINDERS

Compressed gas cylinders are safe for the purposes for which they are intended. Serious accidents connected with their handling, use and storage can almost invariably be traced to abuse or mishandling. The following rules cover the main safety rules to be observed in handling compressed gas cylinders. Some information specific to certain gases is included.

1. Compressed gas cylinders should always be moved using a cylinder cart. A cylinder cart is provided for that purpose in room 38 Hammond. The cart must be returned to that area upon completion of the transfer.
2. All compressed gas cylinders should be securely chained and stored only in approved areas.
3. Do not drop cylinders or permit them to strike each other violently.
4. Make sure the regulator to be used is appropriate for the gas and the cylinder pressure. Regulators or pressure gauges for use with a particular gas must not be used on cylinders containing different gases.
5. After attaching the regulator and before the cylinder valve is opened, see that adjusting screw of the regulator is released. Open the cylinder valve slowly; never permit gas to enter the regulator suddenly.
6. Before the regulator is removed from cylinder, close the cylinder valve and release all gas from the regulator.
7. Never store cylinders near high flammable substances, such as oil, gasoline, etc.
8. All cylinders should be protected against excessive rise of temperature. Cylinders may be stored in the open but in such cases should be protected against extremes of weather (ice, snow, direct sunlight in summer, radiators or open flames, etc.).
9. Store full and empty cylinders in separate locations to avoid confusion. When returning empty cylinders, remove lower portion of the shipping tag attached to the cylinder. Close the valve and see that the protective caps and nuts for valve outlets are replaced before shipping empties.

D. MERCURY SPILLS

The following steps should be taken in case of an accident involving a mercury spill.

1. Do not attempt to clean the mercury in the contaminated area. Mercury breaks into tiny particles and further contaminates the area. Special equipment is needed to ensure that contamination is controlled.
2. Mark the contaminated area.
3. Do not walk on the contaminated area.
4. Turn on the air exhaust if available.
5. Leave the Room immediately.
6. Contact the University Environmental Health & Safety Office immediately (865-6391) and notify the Department as soon as possible.

E. CHEMICALS

When using any chemicals be sure that you are knowledgeable concerning their properties and hazards. Material Safety Data Sheets (MSDS) are available and should be read for all chemicals. The University Environmental Health & Safety Office (865-6391) has a large collection of MSDS and should be contacted for copies. Always wear safety glasses and, if appropriate, suitable gloves or other required clothing. All chemicals should be stored in suitable cabinets. Chemical storage areas, hoods, and work space should be neat and well organized. If any spills or leaks occur, please inform personnel in areas below or adjacent to the spill so that appropriate measures to protect personnel and equipment can be made.

F. ELECTRICAL HAZARDS

1. Only qualified personnel are allowed to work on electrical equipment or energized lines.
2. Sparks or smoke from a motor or other electrical equipment can indicate a shock or fire hazard. Turn off the power at once and report the condition promptly to the electric technician in the department.
3. Electrical equipment should not be operated in wet areas. Experiments using water (water channels or water tables) should be designed extremely carefully in terms of electrical insulations and grounding. Water dripping on electrical machinery (transformers and motors) may cause explosions.
4. Experiments involving electric heater power in excess of 10 KW should be supervised very closely and carefully by the faculty advisor responsible for the facility. Heater connections should be checked thoroughly before switching on the heaters. The power lines should also be protected by appropriate thermal circuit breakers.
5. Electrical equipment with frayed or cracked cords should not be used until the cord is replaced.
6. Maximum attention should be exercised not to have excessive amounts of extension cables lying on the ground level in any laboratory.
7. Remove rings and jewelry which could result in electrical contact while working on electrical equipment.

Acknowledgment

Preparation of this safety manual was aided by reference to the procedures used by the Departments of Engineering Science & Mechanics and Mechanical Engineering. Their careful effort in preparing the original documents is appreciated.

EMERGENCY TELEPHONE NUMBERS

POLICE SERVICES	863-1111
FIRE or ACCIDENT or GAS LEAK or BOMB THREAT.	911
AMBULANCE	911 or 863-1111
PHYSICAL PLANT (steam, electricity, etc.)	865-4731
ENVIRONMENTAL HEALTH & SAFETY	865-6391

EMERGENCY PROCEDURES IN CASE OF FIRE

Location of nearest fire extinguisher (posted in labs)
Location of nearest alarm (throughout building)

- (1) SOUND THE FIRE ALARM
- (2) DIAL 911
- (3) GIVE YOUR NAME AND THE LOCATION OF THE FIRE
(ROOM _____ Hammond Building)
- (4) PROCEED TO THE NORTH EAST CORNER OF PARKING
LOT BROWN A
- (5) DO NOT LEAVE THIS AREA UNTIL INSTRUCTED TO DO
SO BY APPROPRIATE UNIVERSITY OFFICIALS